Enzymatic Processing: past, present, future

Hans Christian Holm

27/06/2011

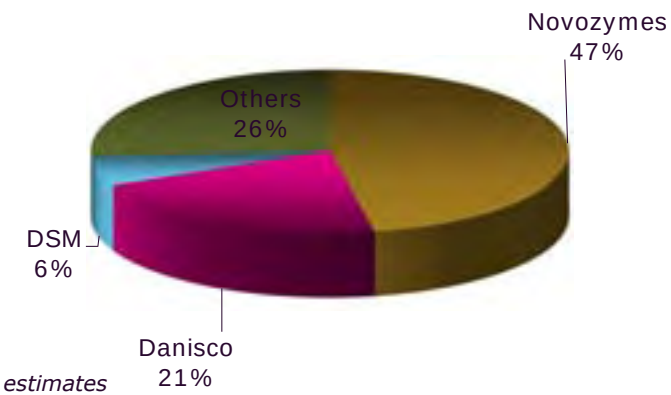
Topics

- What are enzymes?
- Where do we get them and how are they used?
- Current and new processes for lipid processing
  - High purity specialty lipids
  - Improving refining yield
  - Interesterification for high quality bulk fats
  - Improving fish oil processing
  - Improved oleochemicals
  - Improved raw material flexibility for biodiesel
- Conclusions

Novozymes in brief

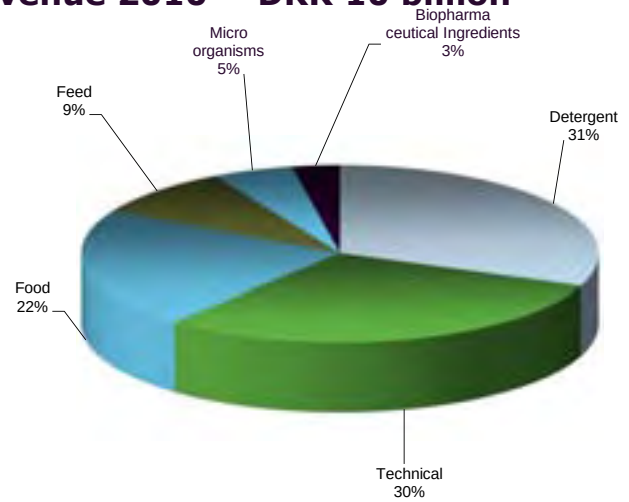
- World leader in industrial enzymes & microorganisms and market leader in all industries where present
- More than 700 products used in 130 countries in 40 different industries
- R&D activities in 5 countries
- 13-14% of revenue invested in R&D
- New products represented around 25% of total sales
- More than 6,500 granted or pending patents
- 43 new products launched during the last 5 years

Enzymes for industrial use
Market size ~ DKK 19 billion



Source:
Novozymes' 2008 estimates

Novozymes' business composition
Revenue 2010 ~ DKK 10 billion

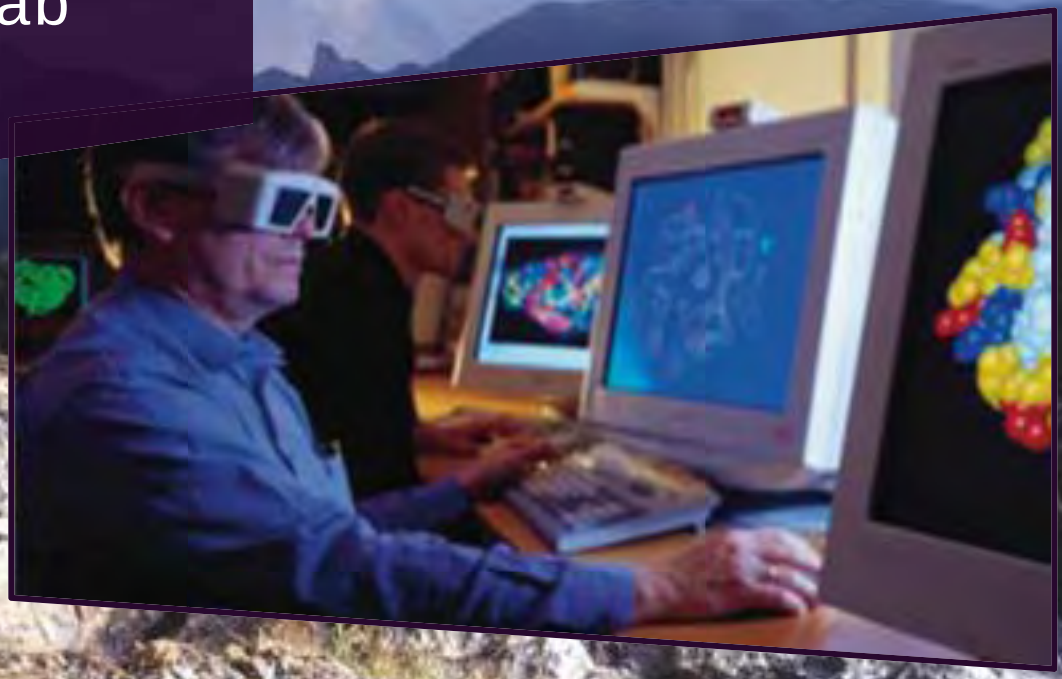


What are enzymes?

- **Biological catalysts in the form of proteins, which drive chemical reactions**
- **Nature's own ingredients. Fully biodegradable**
- **Advanced biotech solutions, replacing chemicals in industrial production**

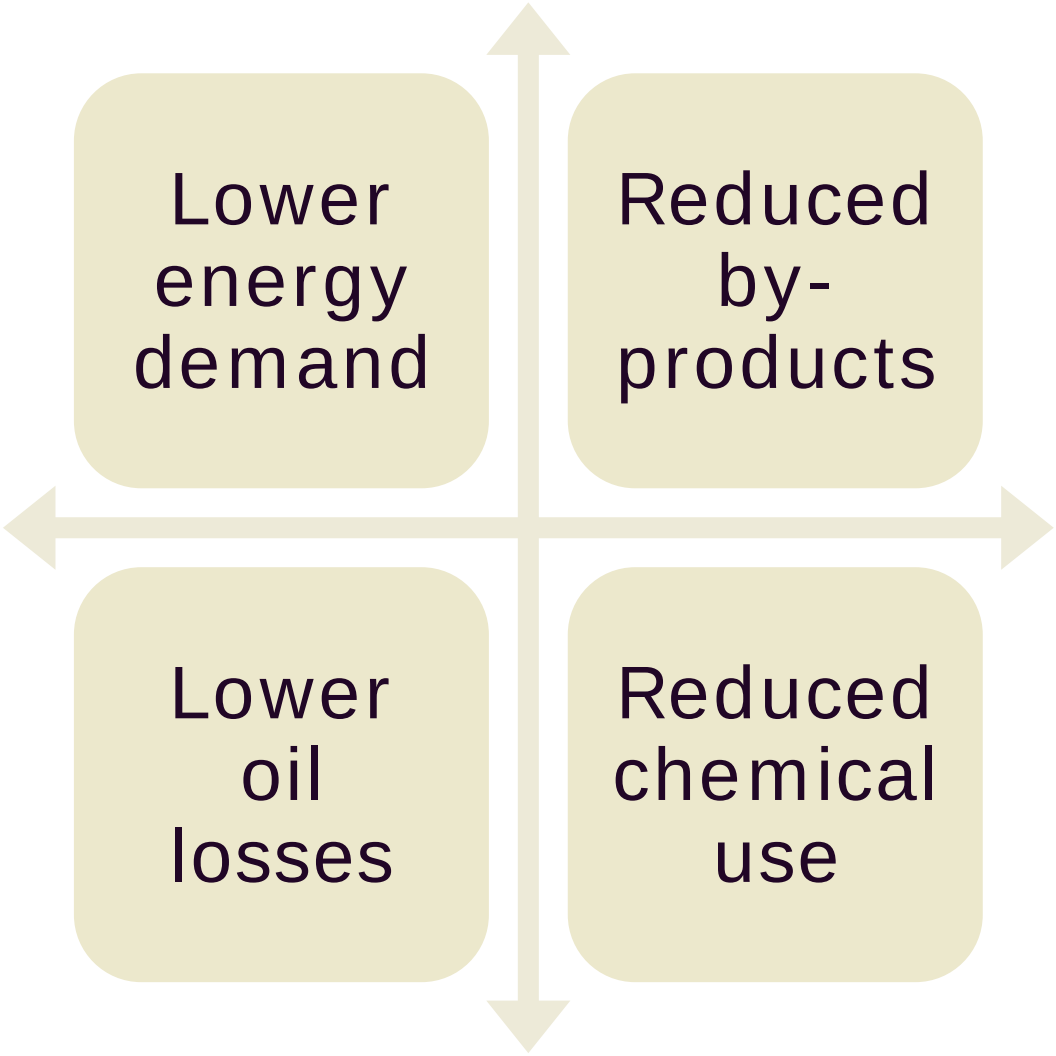
Found in nature…

Refined in the lab



How we produce enzymes

Why are enzyme processes attractive?



Cocoa butter equivalents

Lipozyme®

In the old days…

… Cocoa Butter Equivalents were made from Shea nuts . The tree grows widely and naturally in West Africa..

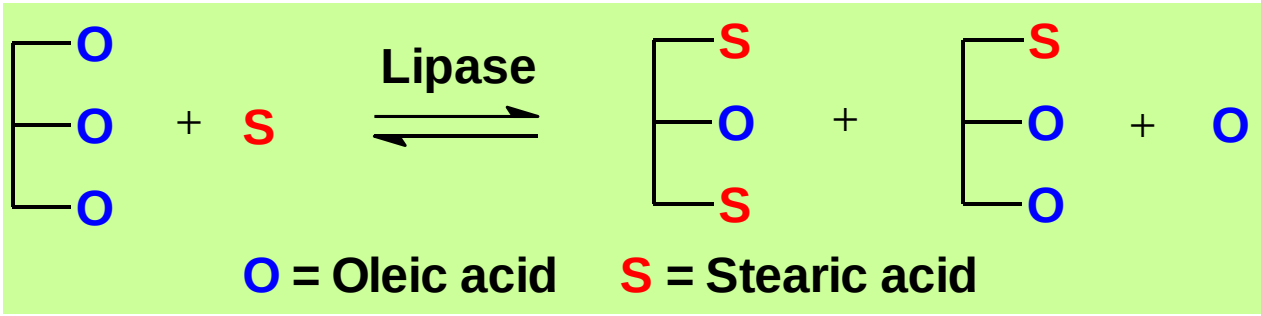
But even as demand for CBE grows the supply of nuts become increasingly unstable

With bioinnovation…

… Cocoa butter Equivalents can be made from abundant vegetable sources

The chemistry behind Structured fats

Use of 1,3 specific lipases enable production of structured lipids



Infant milk replacers like Betapol

In the old days…

Babies were given standard cows milk

But cows milk do not have the proper fat structure for infants.

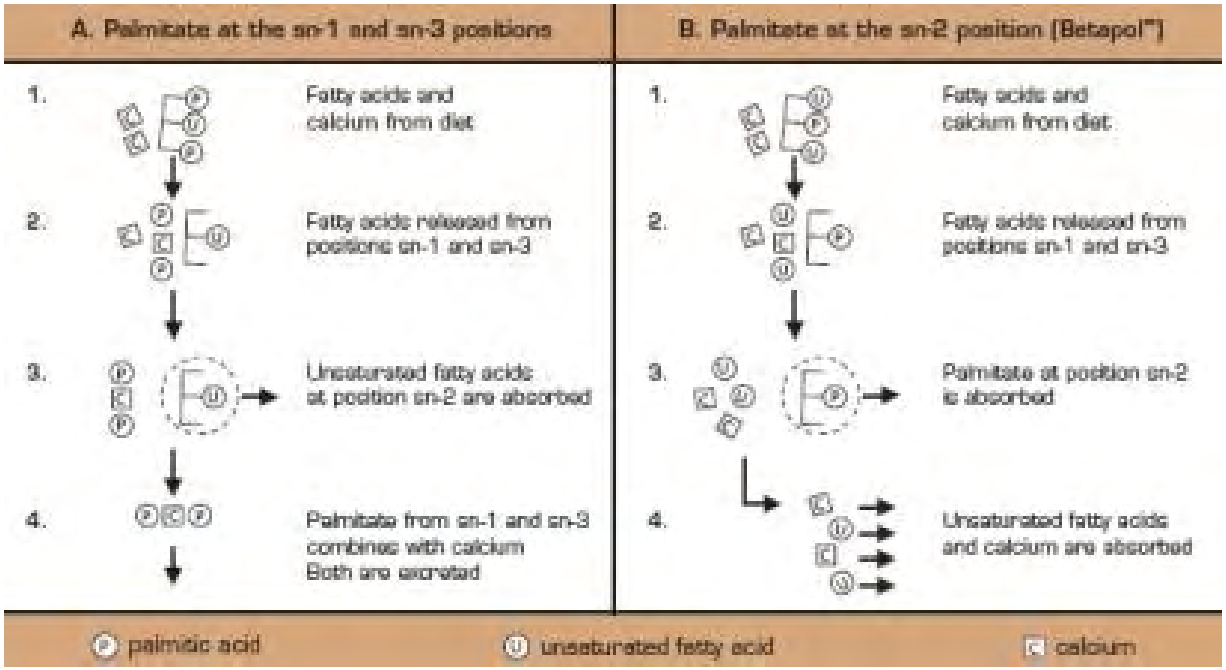
With bioinnovation…

… The fat structure in Betapol® matches the structure of breast milk fat as closely as possible.

As no harsh treatment is involved, high quality products suited for infants can be made.

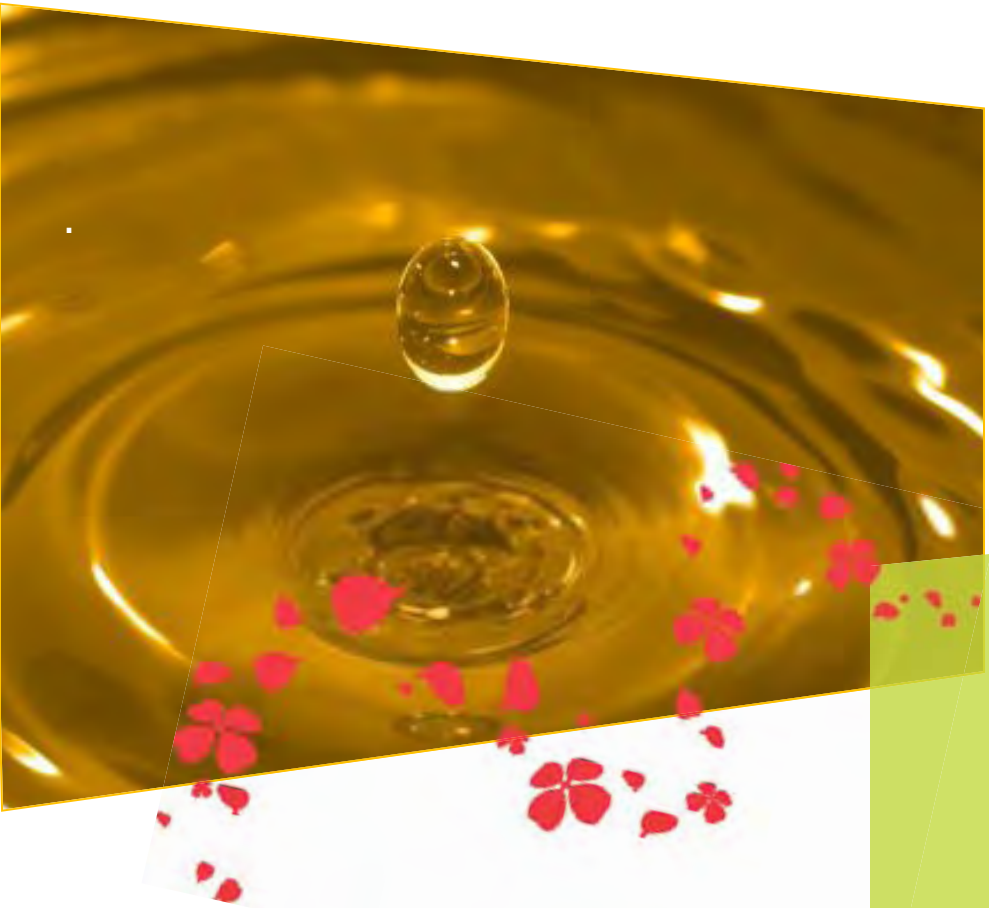
The chemistry behind structured lipids

Using 1,3 specific lipases structured lipids for special nutritional purposes can be made.



From Betapols Homepage

Enzymatic degumming of vegetable oil



Lecitase®

In the old days…

… degumming of vegetable oils was achieved using alkaline processes.

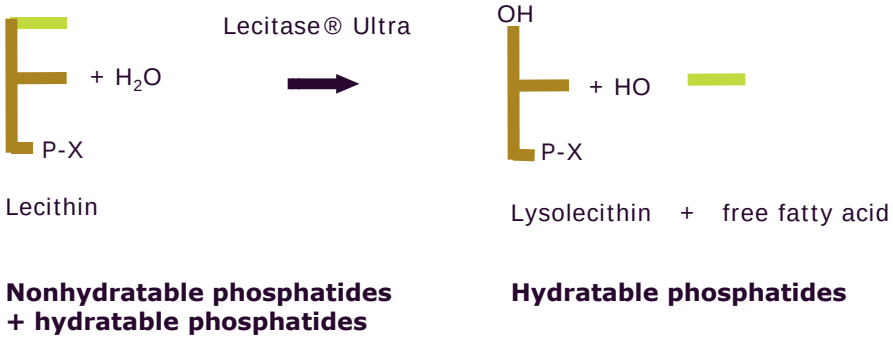
This used large amounts of water and energy

With bioinnovation…

… enzymatic degumming of oils makes it possible to increase vegetable oil yield

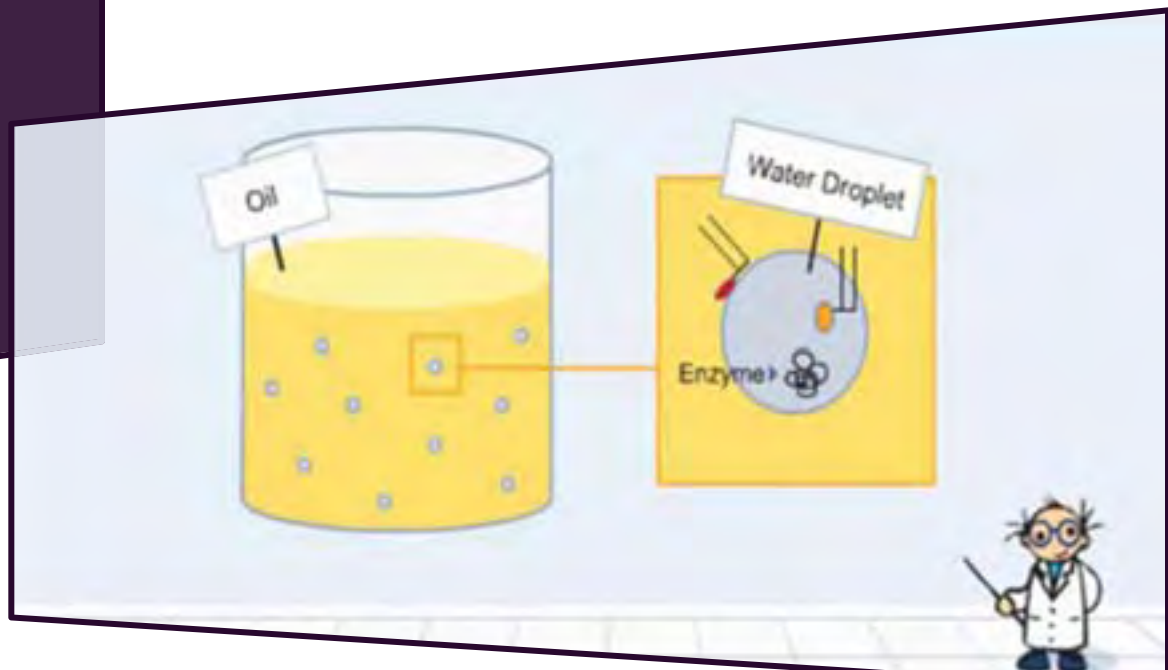
Enzymes also use less water and energy to degum the oil, and they reduce the amount of chemicals going into the wastewater system.

Enzymes increase refining yield and profit



Benefits:

- Reduced oil losses
- Low water consumption
- Less chemicals
- No soap-stock
- Improved retention of tocopherols and sterols



Enzymatic degumming reduce oil losses and chemical consumption – **Significant yield improvements**

Oil losses are virtually eliminated because:

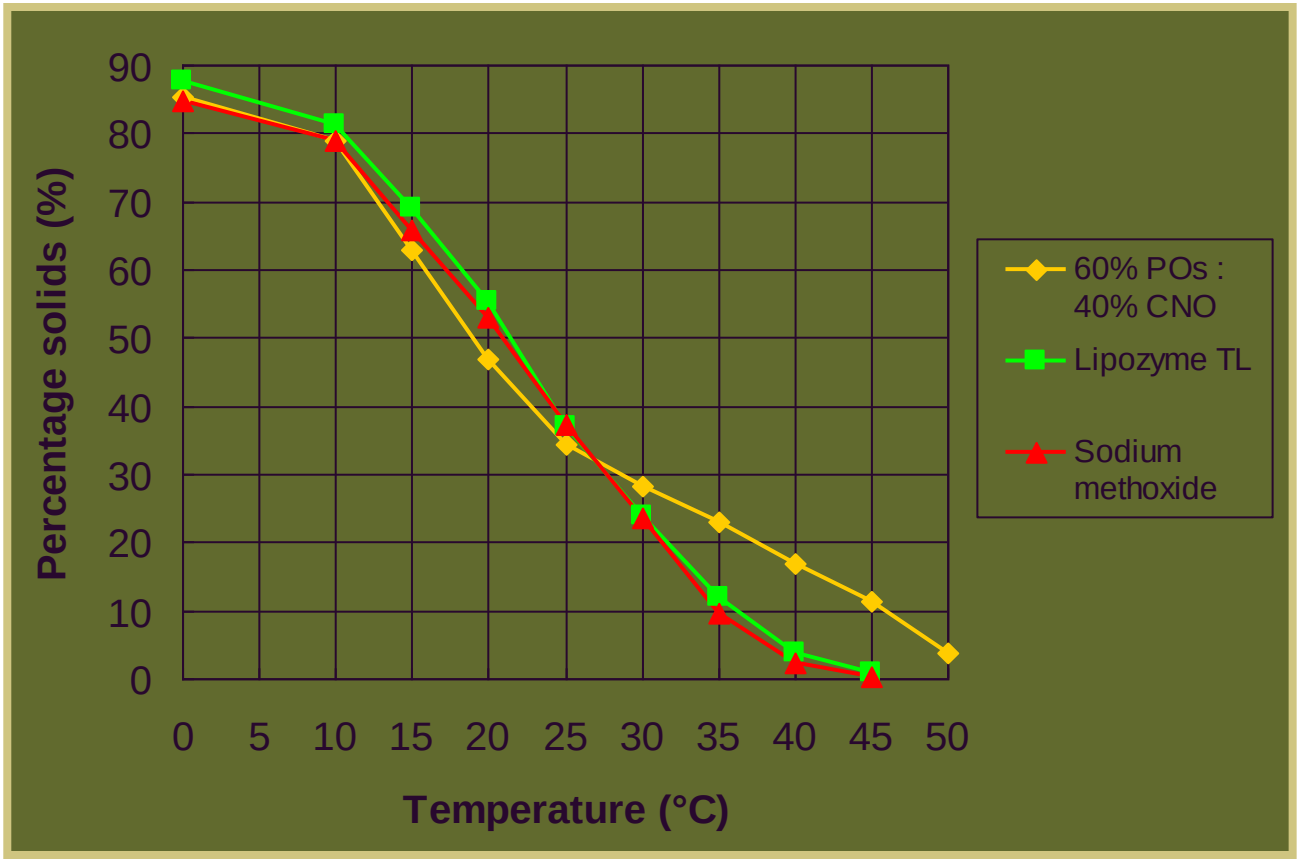
- The gum phase becomes hydrophilic and does not bind oil
- The gum volume is reduced and is virtually oil free ~1% yield gain
- Low carry over of acids in oil phase

From left to right: sediment of soybean oil from lab tests. Left (2% water) and right (2% water with Lecitase® Ultra)

Enzymatic interesterification

Chemical and enzymatic interesterification give more or less identical Solid Fat Contents curves

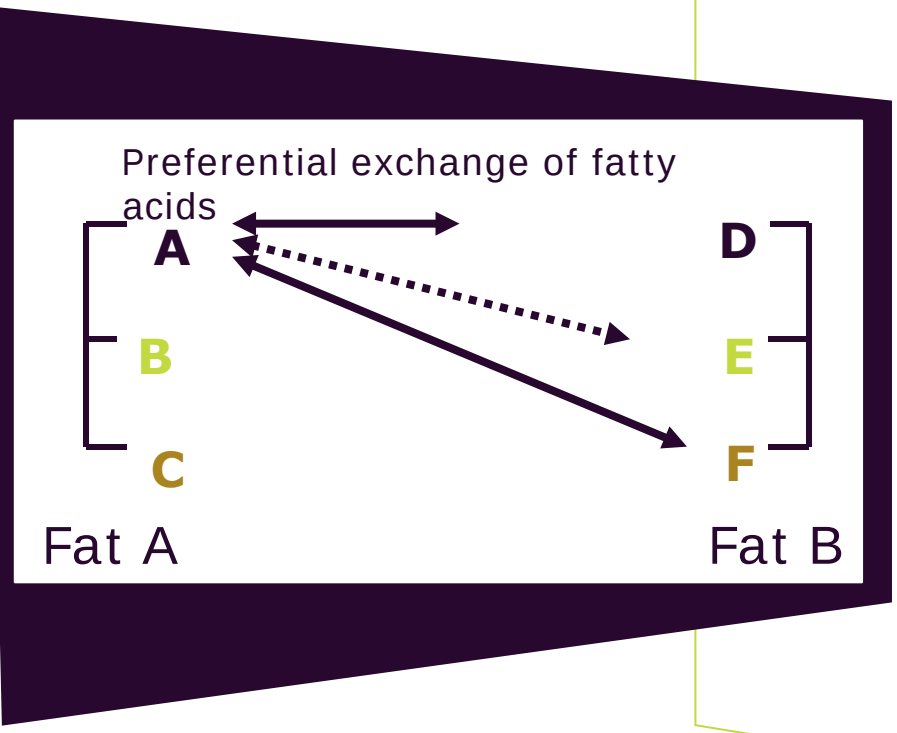
Palm Stearin/Coconut (60/40)



Lipozyme TL IM: 8 %, @70°C, 360 minutes, Dropping-point = 39.1°C

0.5% $NaOCH_3$, @100°C, 30 minutes, Dropping-point = 39.2°C

The chemistry behind enzymatic re-arrangement



A process that uses immobilized lipases to Re-arrange the fatty acids between a hard fat and an oil and thereby produce a desired melting profile

The enzyme is held in columns with the oil blend to be interesterified, fed in counter-current mode

A lower-energy process without by-products and minimal post processing clean up of oils

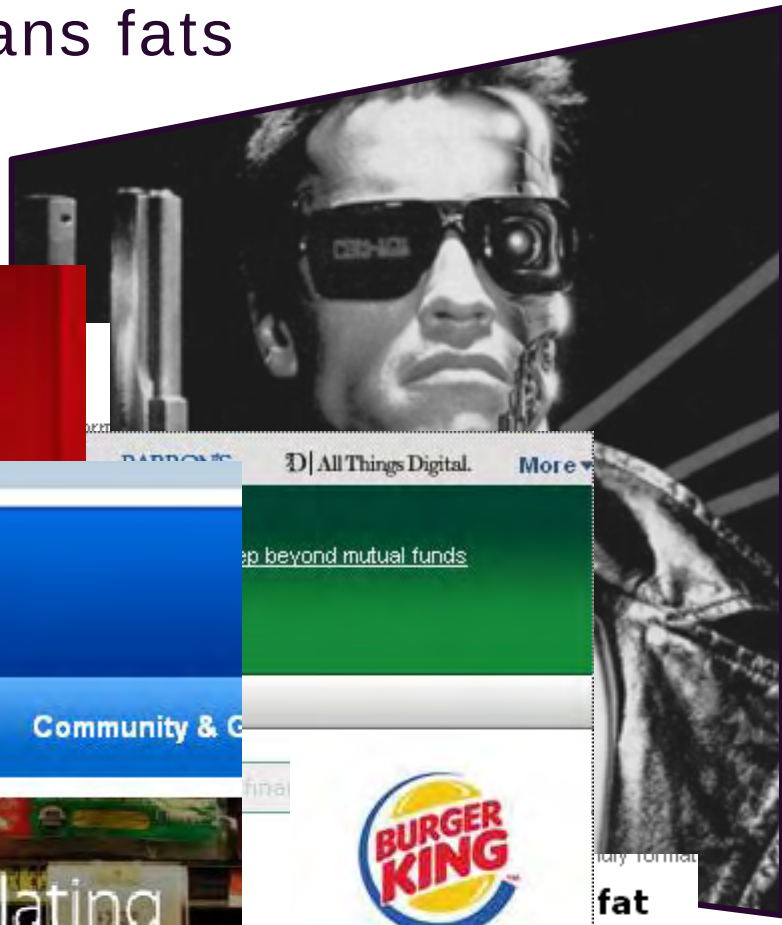
Increasing publicity to remove trans fats

Health and Behavior | Inside News

NYC bans trans fats in restaurants

Updated 12/6/2006 7:50 AM ET

Calif.



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d the rollout of a trans-fat-

fat

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Enzyme benefits in production of fish oil concentrates

- Simple processes
- Purer end products
- Improved yield

Production of fish oil concentrates

- **Deacidification/**
  - Alkaline refining
    This step refines the crude oil by removing free fatty acids and impurities.
  - Stripping
    The stripping step is a highly specialized process which removes the environmental pollutants and cholesterol from the refined fish oil.

1% FFA ~ 2% yield loss.
@ 2.500 USD/ton
~ 50 USD/ton loss

- **Ethyl transesterification**
  In this step, the triglycerides in the de-acidified and stripped fish oil react to form ethyl esters.

Chemical yield less than 95%.
We can do better!

- Distillation
  An evaporation and condensation process conducted at an extremely low pressure to increase the omega-3 concentration.
- **Condenzation**
  An evaporation and condensation process conducted at an extremely low pressure to increase the omega-3 concentration.

Well established application running at more than 10 plants

Improved cosmetic ingredients

In the old days…

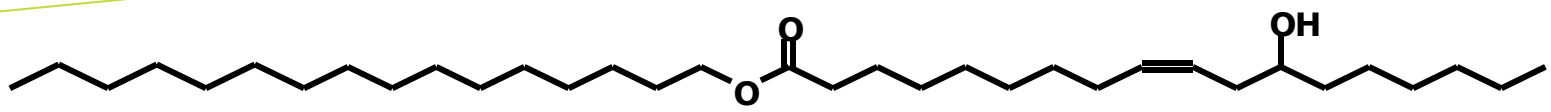
… High temperature processes were used to make cosmetic ingredients

With bioinnovation…

… oleochemiclas can be made in simple processes.

As no harsh treatment is involved, high quality cosmetics ingredients with a better color and improved purity.

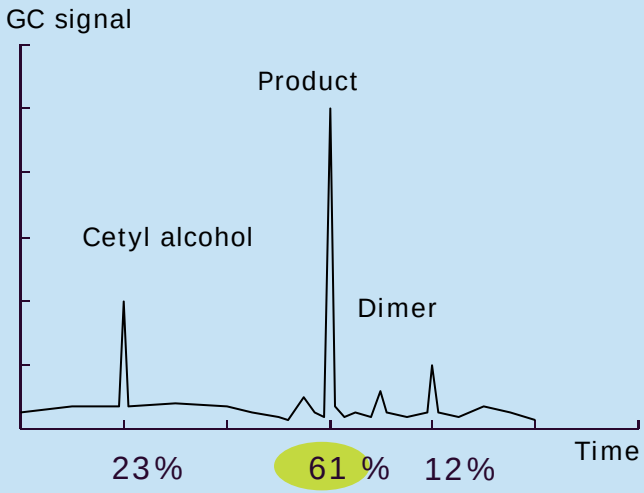
Oleochemicals – improving product quality and yield



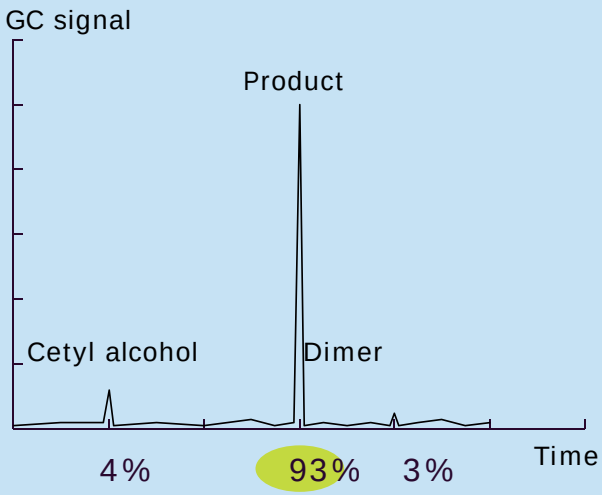
Cetyl ricinoleate, a cosmetic wax (Tegosoft® CR)

With lipases we can simplify the production process while improving Yield, product qulity and environmental impact.

Conventional product



Enzymatically produced Tegosoft® CR



From Evonik presentation

Future

Making diesel naturally

Mixture of lipases

In the old days…

… diesel was a by-product of the production of petrol from crude oil.

Diesel fumes emit harmful particles that are carcinogenic and lead to smog formation.

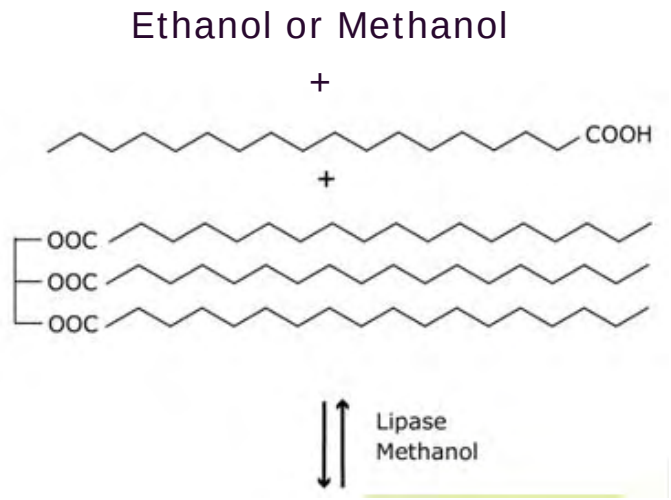
With bioinnovation…

… diesel will be biodiesel made from vegetable oil or animal fat.

Biodiesel reduces greenhouse gas emissions and is made from renewable resources.

Enabling use of lower grade rawmaterials for biodiesel

Feedstock	Price (EUR/ton)	(Mt / year)
Animal fat	500-700	20
Used cooking oil	600-700	1
Acid oils	200-300	1
FAD	400-500	2.5
High FFA oils	<700	
Virgin oils	830-890	



Free fatty acids

Oils & fats

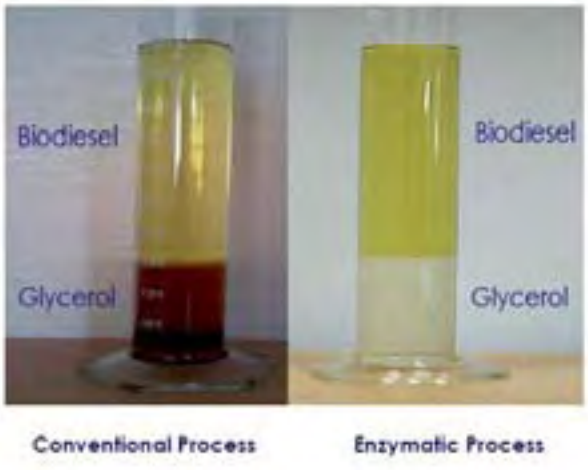
Advantages and challenges for enzymatic biodiesel

Advantages

- Renewable catalyst
- High levels of free fatty acids in raw material – no issue
- Possible to use ethanol
- Savings in energy and water
- High glycerol purity
- Low reaction temperature
- Improved CO_2 foot-print

Key challenges addressed

- Getting in-spec biodiesel
- Long reaction time
- Cost
- Investment to retrofit plants



>50 plants World-wide Use our enzymatic solutions to improve their oil & fats processing

novozymes
Rethink Tomorrow

★ Enzymatic Degumming plants

★ Enzymatic Interesterification plants

● Synthesis and modification plants

★ Pilot biodiesel plants

Conclusions

- Enzymatic degumming improve process yield and deliver a high quality feed stock for traditional biodiesel production
- High quality margarines and shortenings free of trans fatty acids are produced in cost competitive process
- Fatty acid ethanol esters (and FAME) can be produced enzymatically according to ASTM specifications.
- The economy suggests the enzymatic process for biodiesel will become cost effective.
- Enzyme technology can improve the environmental sustainability of the biodiesel production and the use of the fuel.

"An invasion of armies can be resisted, but not an idea whose time has come."

Victor Hugo

Use enzymes to enhance your business, and reap the benefits of modern biotechnology.

Thank you!