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Global Innovation



Enzyme Degumming for Physical Refining

SCI
Enzymatic Processing and Modifications-
Current and Future Trends
Het Pand, Univerisity of Ghent, Belgium
21 June 2011

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Overview

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- Physical Refining
  - Phospholipid Chemistry
  - Enzyme Reaction Fundamentals
  - Process Comparisons
  - Commercial Phospholipase
  - Intellectual Property
  - Enzymatic Degumming
  - Bleaching
  - Deodorization / De-acidification

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Lipids and water affinity

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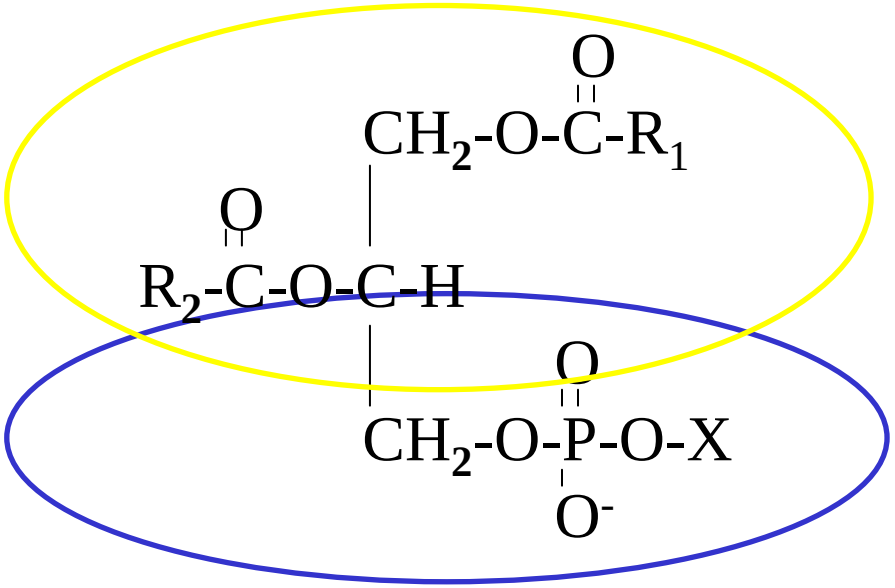
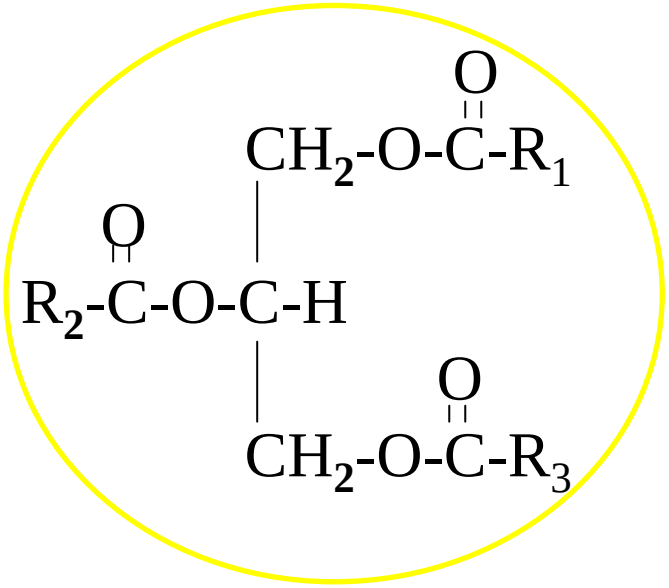
Phospholipid



Triglyceride



water affinity

oil affinity

$R_{\#}$ = fatty acid chains

X = H, choline, ethanolamine, serine, inositol, etc.

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Phospholipids in vegetable oils

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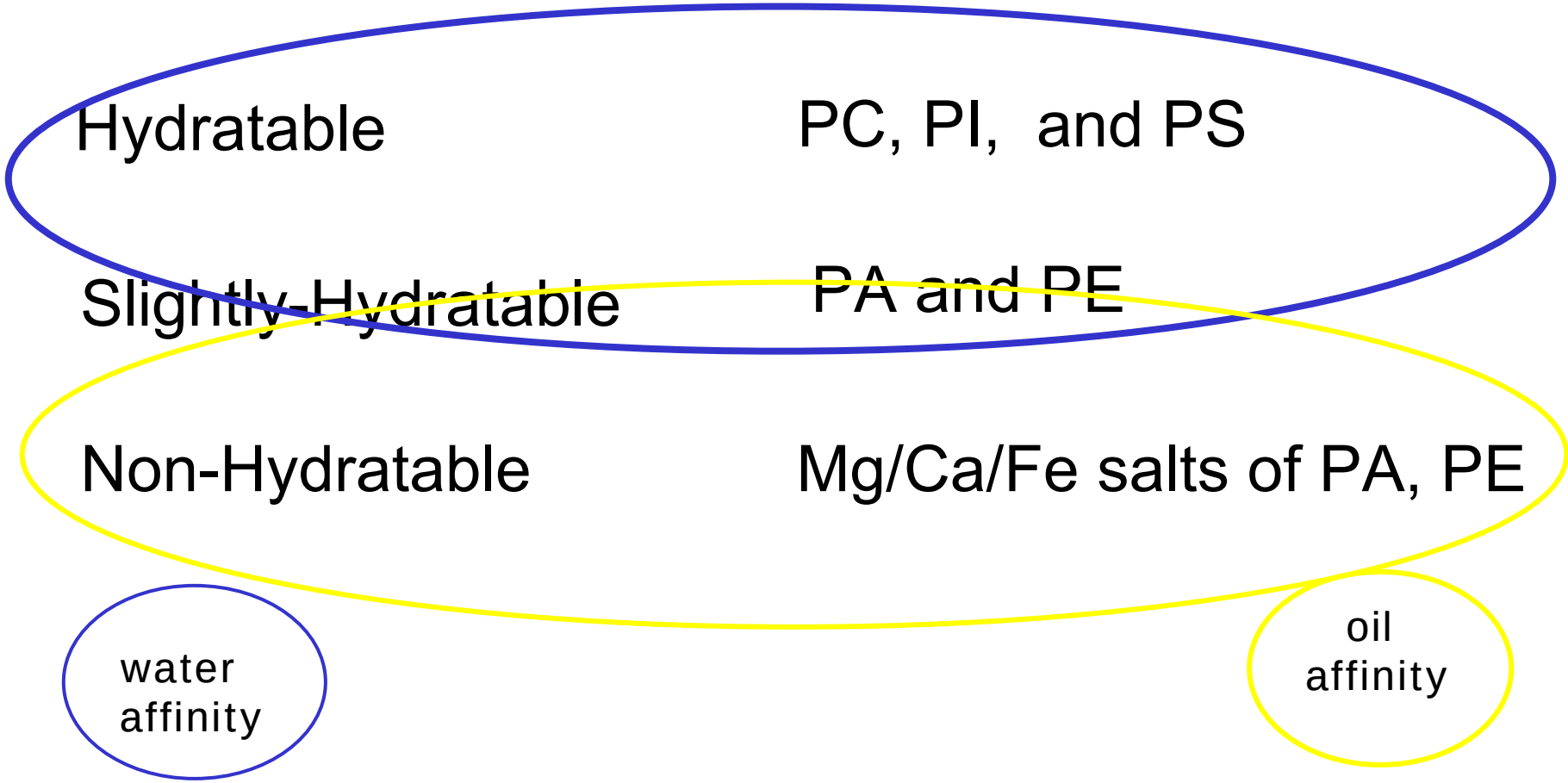

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Hydration

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Phospholipid	Relative Rate of Hydration
PC	100
PI	44
PI (Ca salt)	24
PE	16
PA	8.5
PE (Ca salt)	0.9
PA (Ca salt)	0.6

(1) Sen Gupta, A.K., Fette Seifen Anstrichmittel V.88 pages 79-86 (1986) *in* Segers, J.C., et al., "Degumming – Theory and Practice" published by American Oil Chemists's Society in "Edible fats and Oils processing: basic principals and modern practices: World conference proceedings", edited by David Erickson, (1990) pages 88-93.

Non-Hydratable Phospholipid

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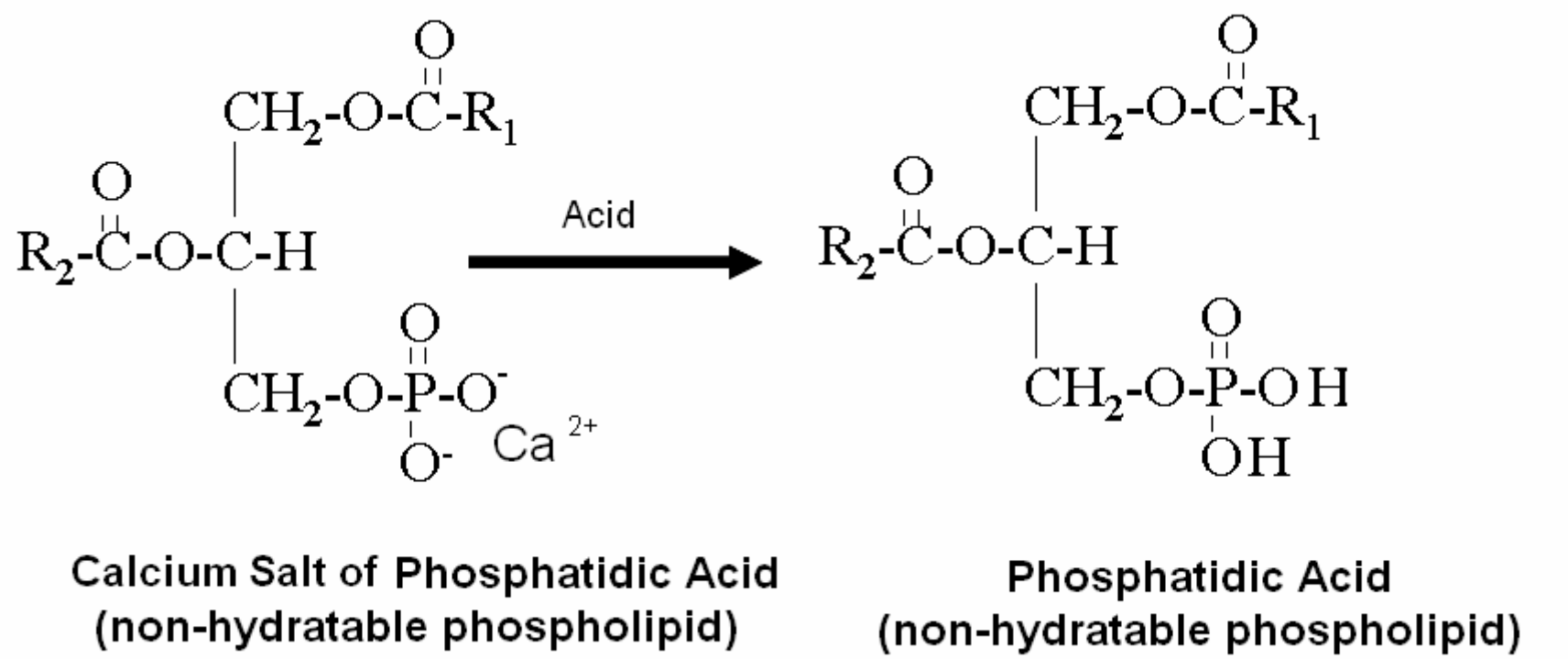

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Phospholipid Hydration

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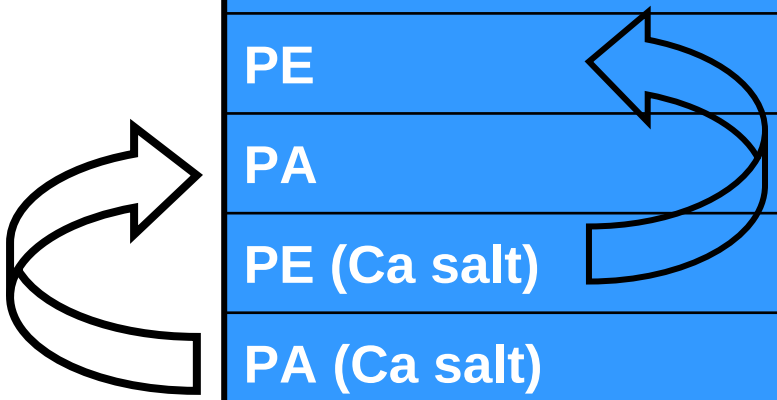

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Enzymatic Refining - fundamentals

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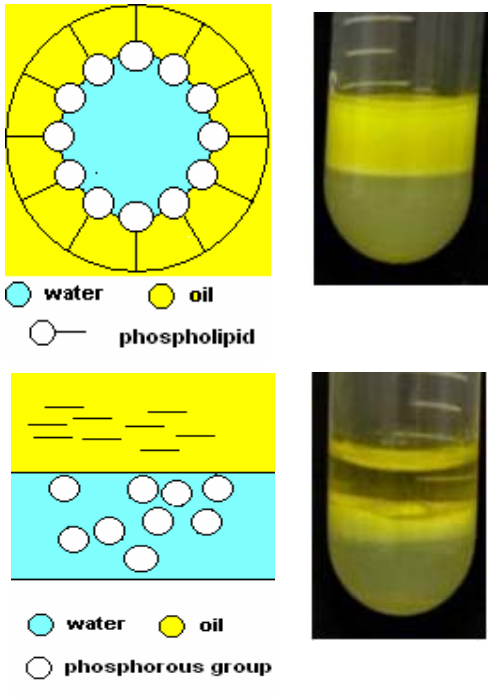

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- In the conventional degumming and chemical refining process, gums work as emulsifiers and are responsible for the major part of the oil losses.

- In enzymatic degumming, the enzyme action eliminates the emulsification properties of the gums. The oil savings are proportional to the phosphorus (gums) in a ratio of 1 (oil) to 2 (gums).

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PHOSPHOLIPASES: mode of action

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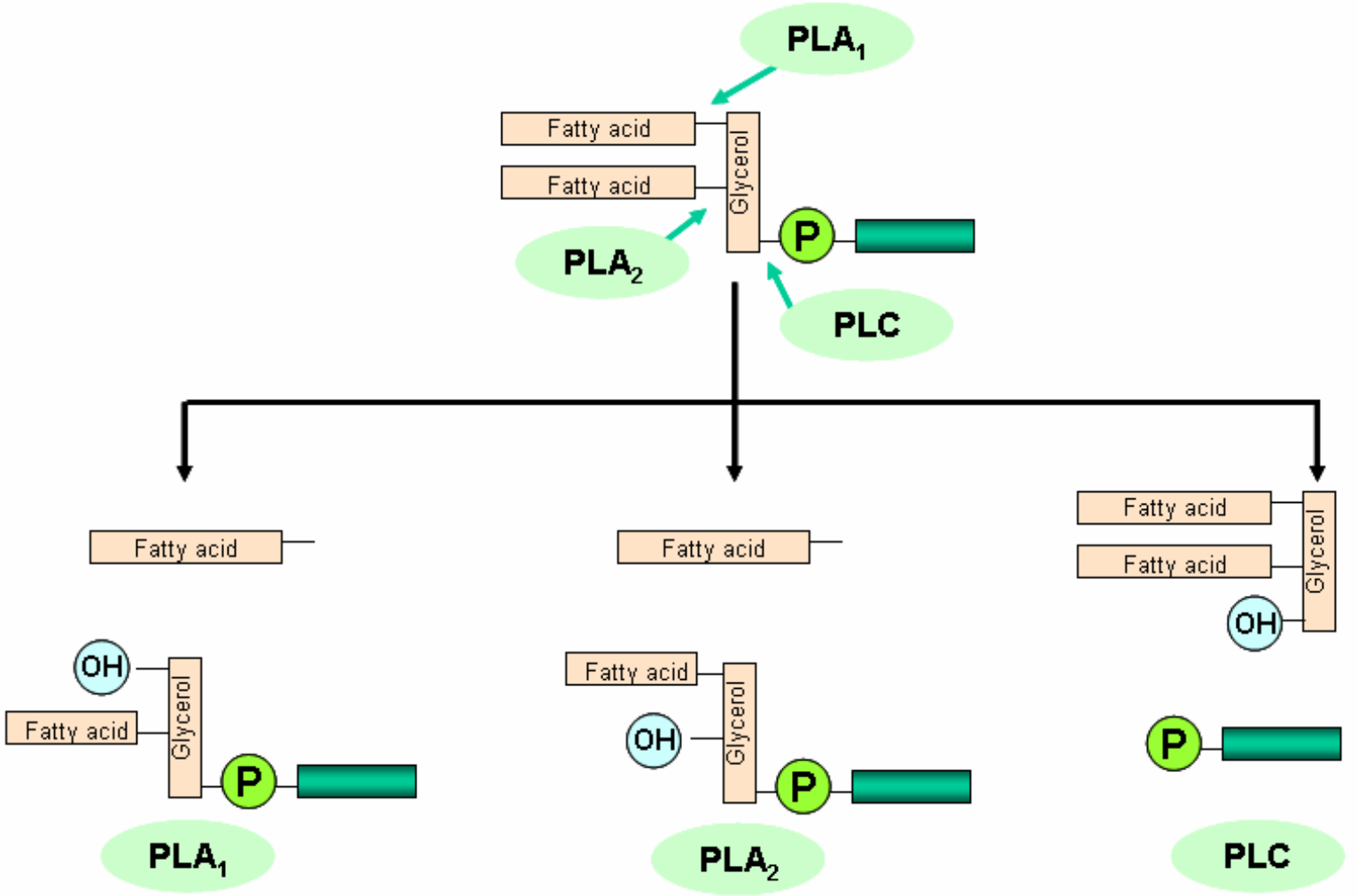

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PLA Enzyme Degumming

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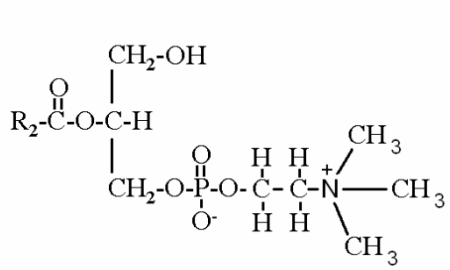
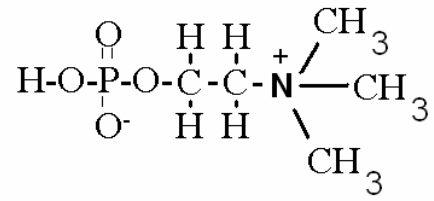
- **Phospholipase A_1**
  - Lyso Lecithin
- **Phospholipase A_2**
  - Lyso Lecithin
- **Phospholipase C**
  - Phospho-species



lyso-Phosphatidyl Choline



Phosphocholine

Photographed by C. Dayton

Comparing Refining Technologies

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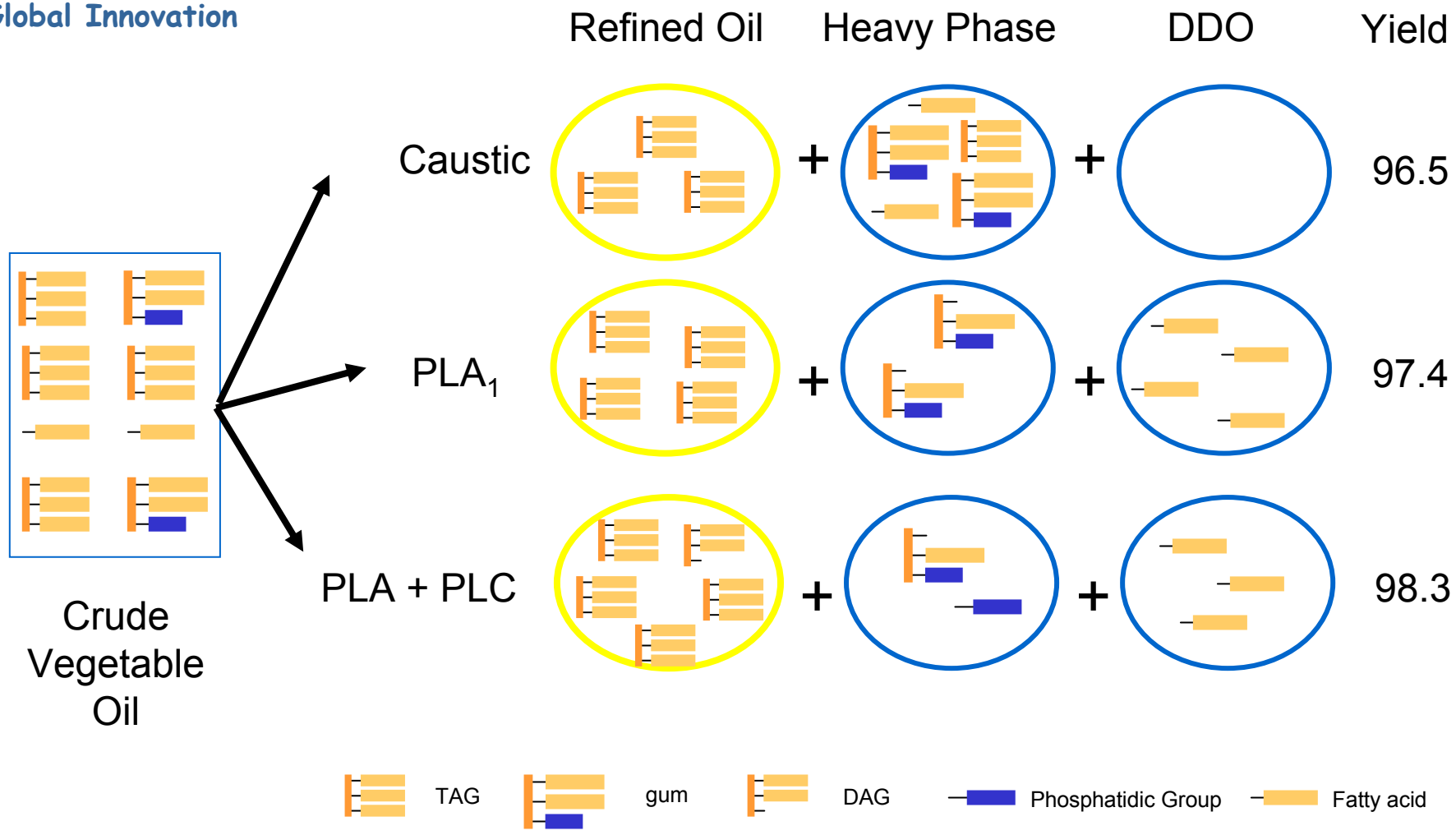

Commercial Enzymes for Oil Refining

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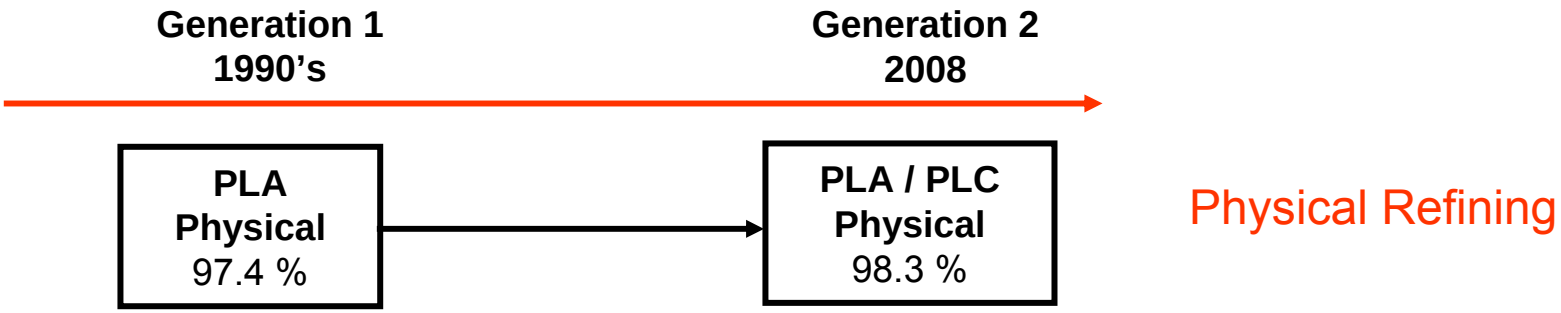
AB Enzymes' PLA_2, Rohalase® MPL

Dansico's PLA_2, FoodPro™ LysoMax

Novozymes' PLA_1, Lecitase® Ultra

Verenium's PLC, Purifine™

DSM's PLA_2, GumZyme™



Physical Refining

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Intellectual Property

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- US 5,264,367 – Aalrust et al.
  - Phospholipase A_2 for degumming
- US 7,226,771 – Gramatikova et al.
  - Phospholipase C
- US 7,713,727– Dayton et al.
  - Antifouling
- US 2008/0182322 – Dayton et al.
  - Combination of phospholipases
- US 2009/0069587 – Dayton et al.
  - Combination of phospholipases with reduced reaction rates

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Optimum Enzyme pH

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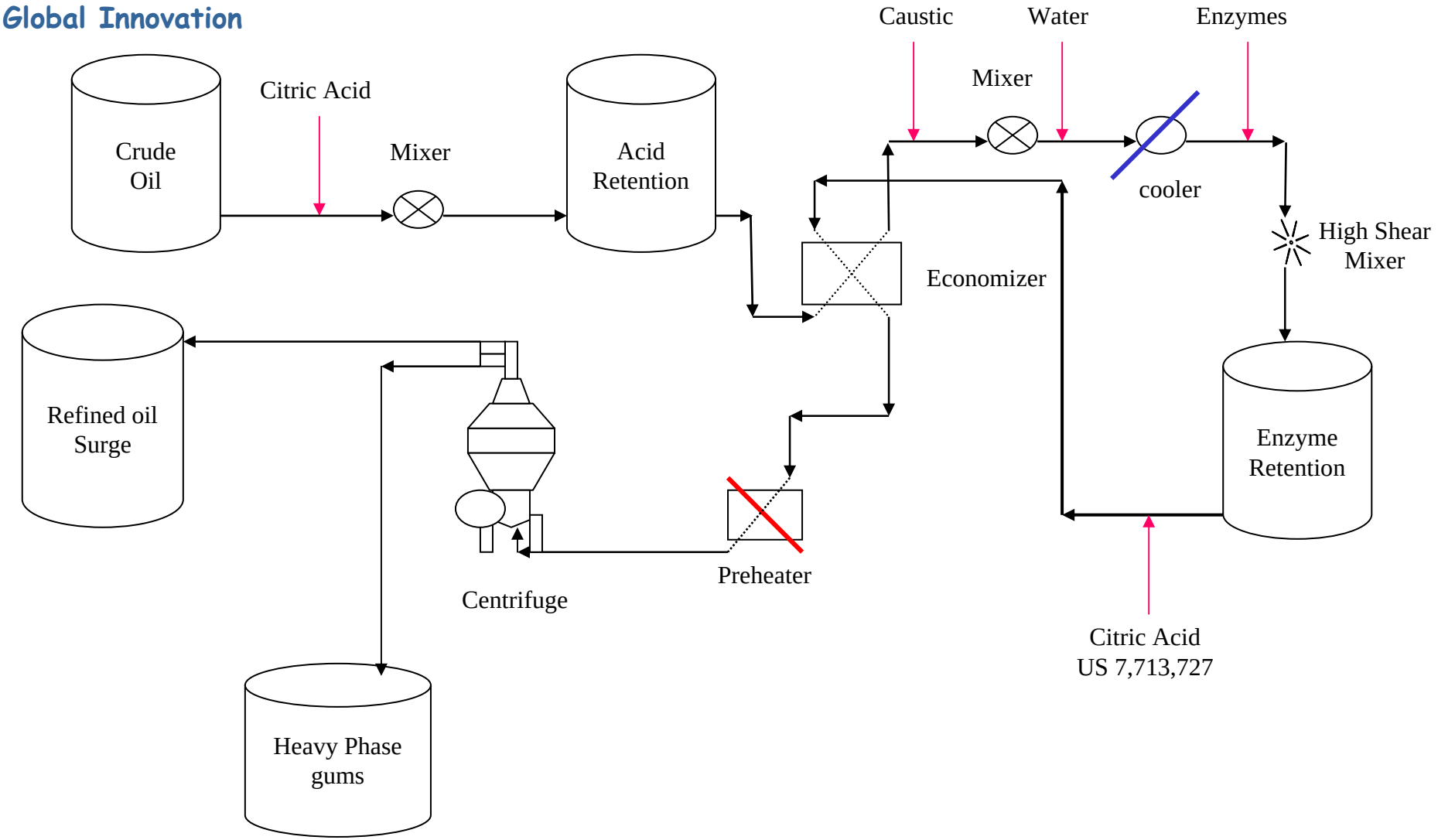

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High Shear Mixing

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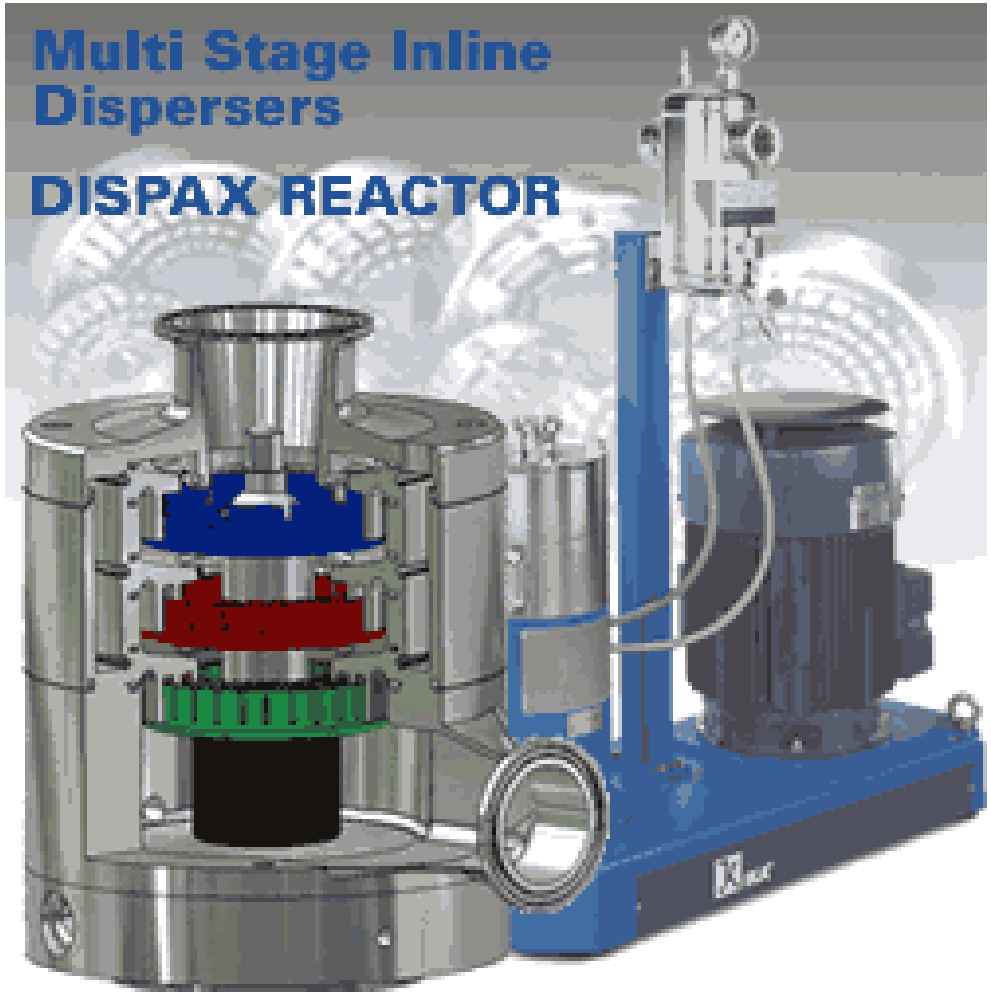

Enzymatic Degummed Specification

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- Phosphorous ≤ 10 ppm
- Calcium ≤ 2 ppm
- Magnesium ≤ 2 ppm
- Iron ≤ 0.001 ppm
- Free Fatty Acid 0.4 – 1.3 %

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Lead-Lag Bleaching

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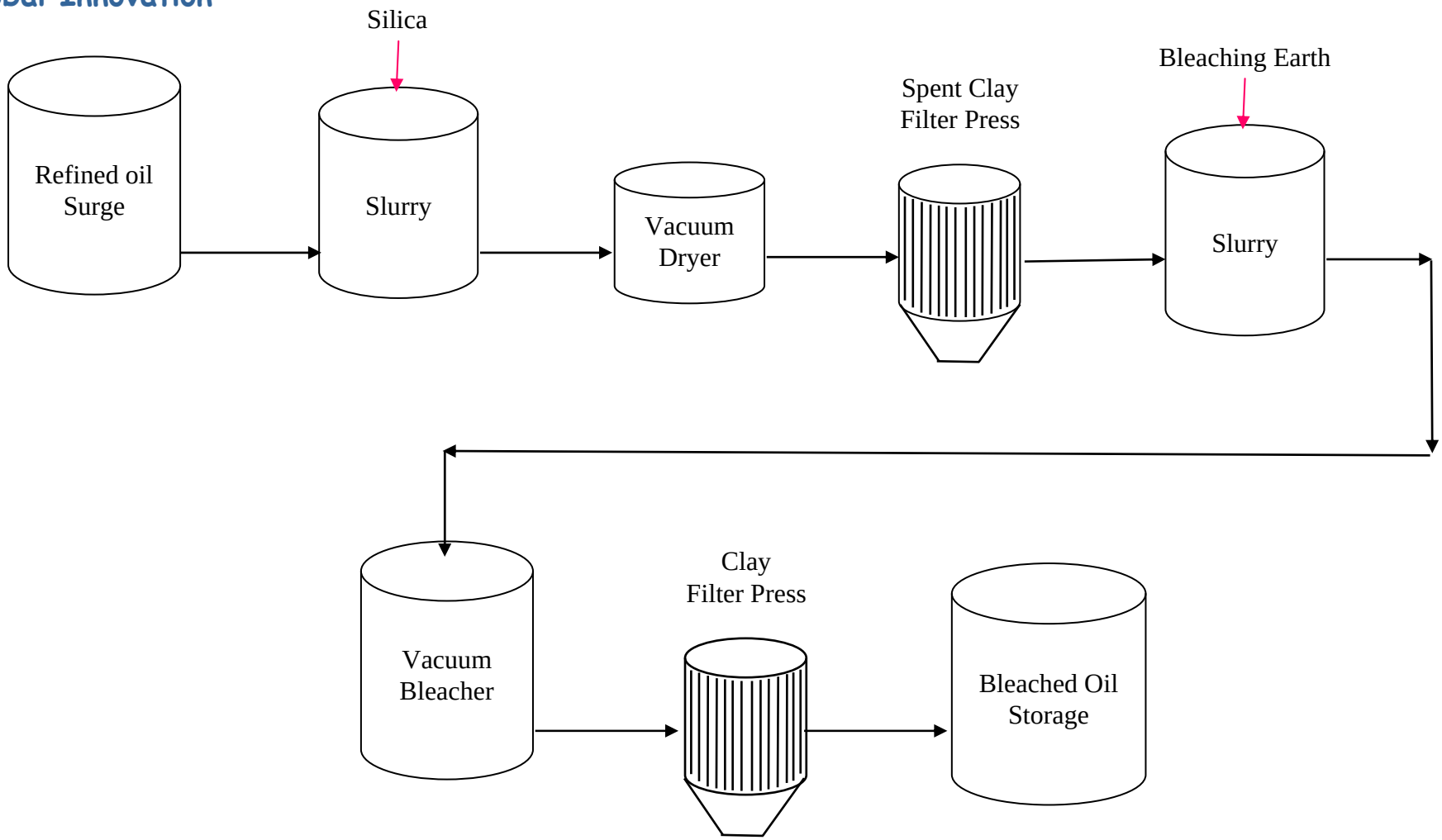

Enzymatic Degummed and Bleached Specification

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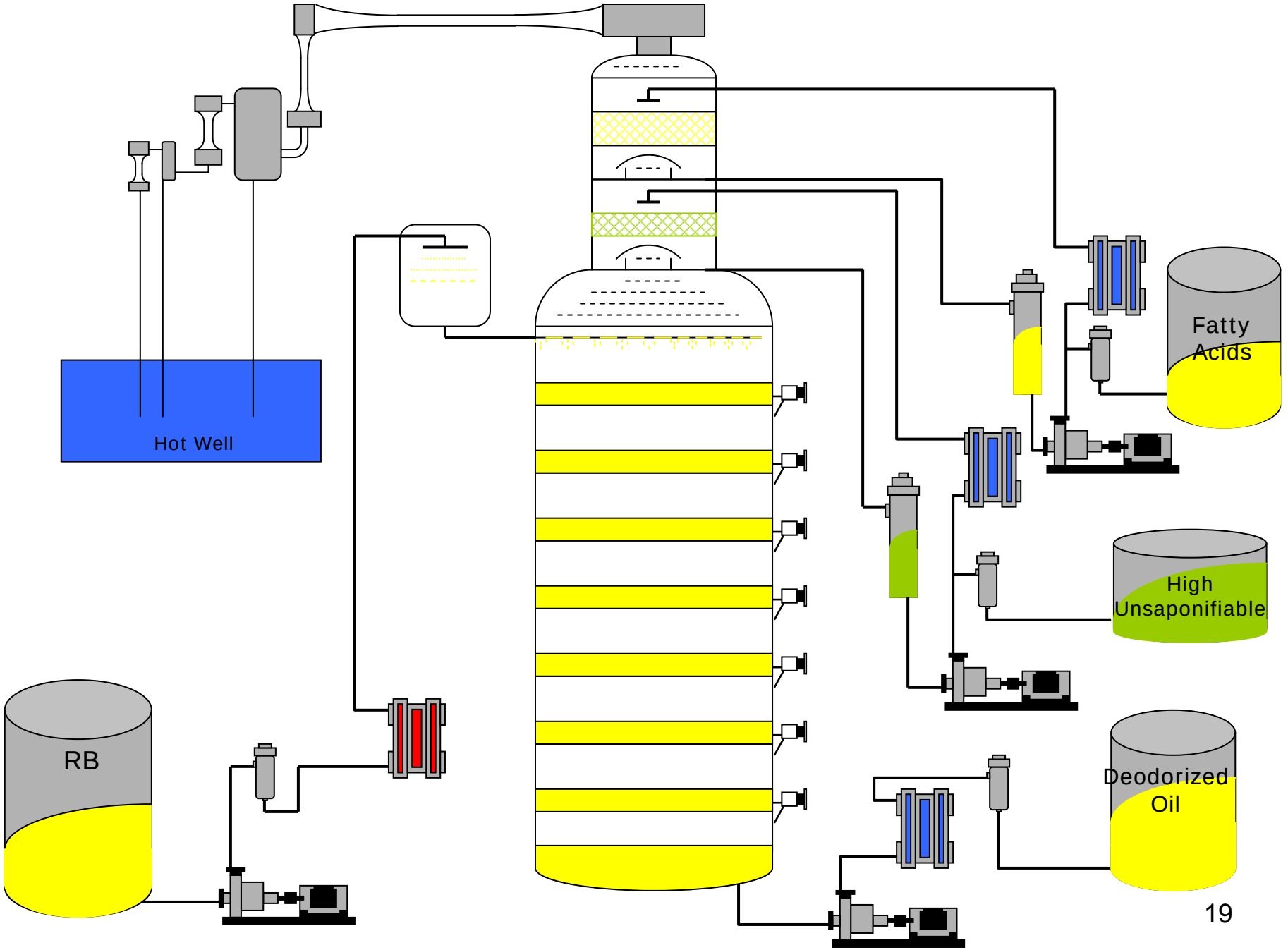
- Phosphorous ≤ 0.5 ppm
- Calcium ≤ below detection limit
- Magnesium ≤ below detection limit
- Iron ≤ below detection limit
- “Chlorophyll” ≤ 30 ppb
- Free Fatty Acid 0.4 – 1.3 %
- Peroxide Value 0 meq/kg


Hot Well
Fatty Acids
High Unsaponifiable
RB
Deodorized Oil

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Physically Refined Specification

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- Flavor – Bland
- Free Fatty Acid 0.05 % max
- Peroxide Value 0 meq/kg
- OSI ≥ 6 hours at 110° C (typically ≥ 8.5)
- Tocopherols ≤ 800 ppm
- Lovibond Color
  - Red ≤ 1.0 (typically 0.3)
  - Yellow ≤ 10 (typically 2.0)

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Enzyme Refining – Industrial Scale

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Advantages

- no soapstock
- no washwater
- *lyso*-gums and / or phospho-species
- reduced process time
- reduction in chemicals
- robust

Bunge Physical Refining Plant

	Caustic Refining	PLA Enzymatic Refining	PLA / PLC Enzymatic Refining
Starting Phos level in crude oil	**500 ppm**	**500 ppm**	**500 ppm**
Phos level after centrifuge	**2 ppm**	**2 ppm**	**2 ppm**
Centrifuge Discharge (dry %)	**3.19**	**1.13**	**0.62**
Yield of oil (%)	**96.5**	**97.4**	**98.3**

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Physically Refined Soybean Oil

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Physically Refining Plant continuously operated since 2003 producing greater than 3,500,000 tonnes of commercial salad oil to customers.

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Thank You!

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Photograph by P. Dayton in October 2010 in Cancun, Mexico.