Industrial production of lecithin and its derivates

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Øresund Food Network – AOCS Phospholipid Seminar

Topics

1. Vegetable Lecithin Sourcing
2. Production
3. Phospholipid Modification
4. Emulsifying Characteristics
5. Selected applications

Source of Phospholipids

- Vegetable Lecithins
- Egg Yolk Lecithin
- Sphingolipids (dairy)
- Marine Phospholipids
- Phosphatidylserine (PS)
  - Brain PL discontinued
  - Enzymatic processed PS from Soy lecithin
- Synthetic Phospholipids

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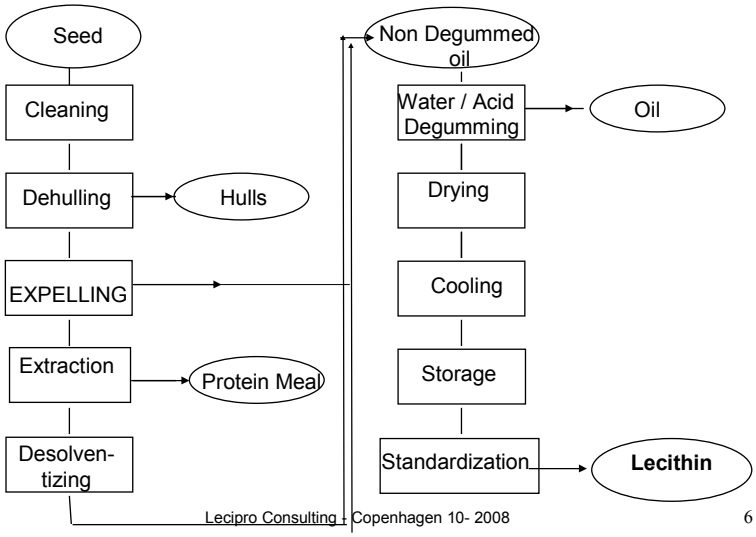
Production of Vegetable Lecithin

- Oil seeds are the primary source
  - Identity Preservation Tracing Systems
- Lecithin occurs in oil seeds at 0.6 – 1.5%
- Crushing opens the cell walls
- Lecithin recovery 0.3 – 0.6%

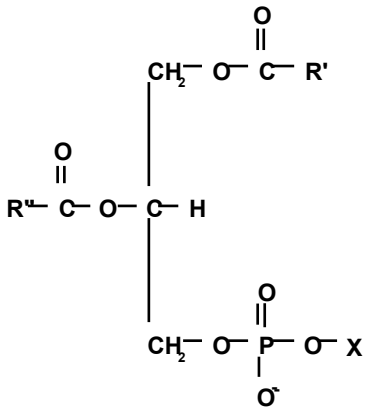
- Beyond 280 million T oil seeds are crushed

- Most oil-soluble phospholipids ”follow” the oil and must be removed before oil refining

Processing of Vegetable Lecithins

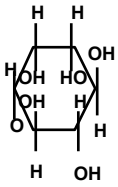


Molecular structure of phospholipids



X = $CH_2-CH_2-N^+(CH_3)_3$ **Phosphatidylcholine**

X = $CH_2-CH_2-N^+H_3$ **Phosphatidylethanolamine**

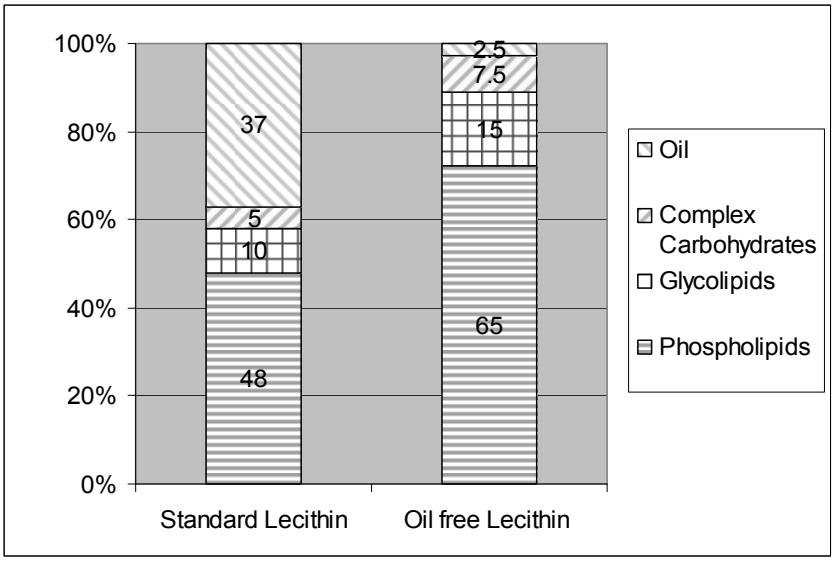
X =  **Phosphatidylinositol**

R'— CO, R''— CO : Fatty acids **X = H: Phosphatidic acid**

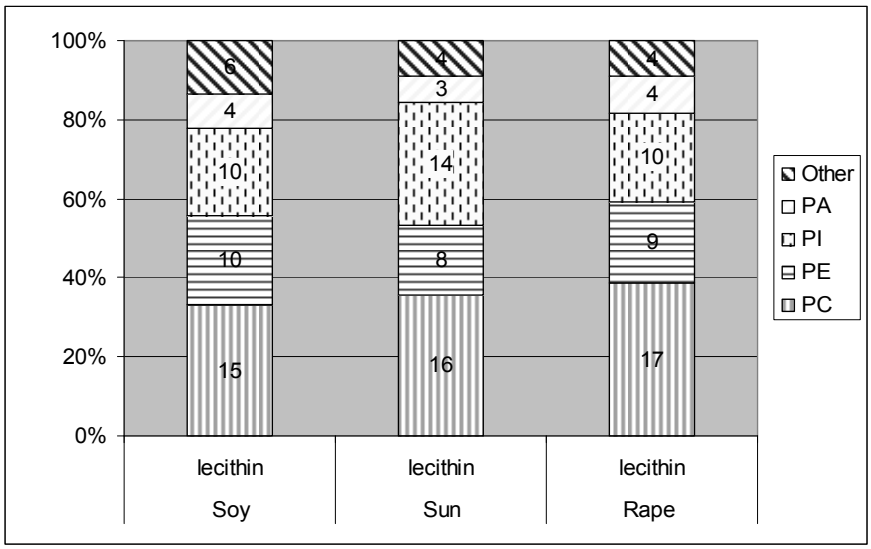
Analytical Methods for Phospholipid Composition

- DGF F-1 6a [00] = AOCS Ja 7c-07 official methods HPLC –LSD separates 7 PL classes;
  - not all “lyso phospholipid” peaks separated precisely with stable base line
- 31P-NMR is most accurate quantitative method for all (15) PL classes
- Information on all types on chemical and physical analytical methods for lecithin: www.ilps.org

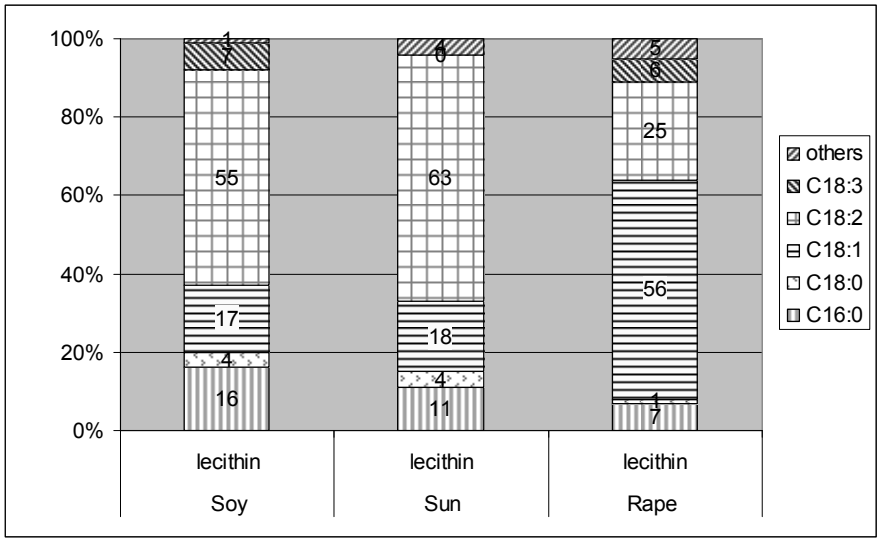
Composition of soy lecithin



Phospholipids in vegetable lecithins



Fatty acid division in lecithins



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Modification Technologies of lecithins

OBJECTIVE:

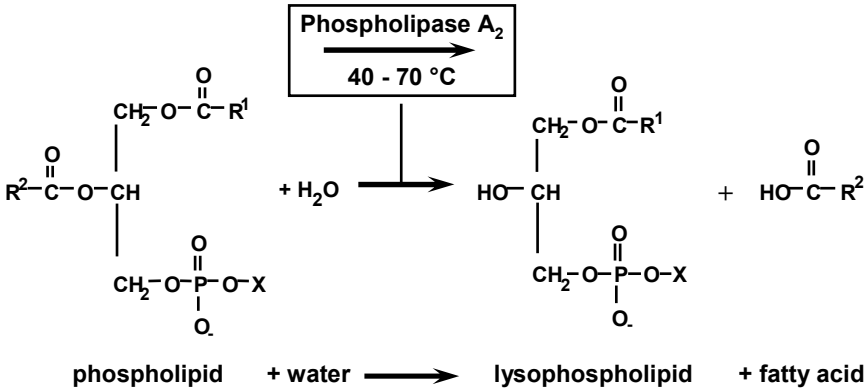
- different hydrophilic - lipophilic character - HLB
- modify PE molecule
- reduce Calcium sensitivity

PRODUCT RANGE:

- clear standard lecithins - 35% oil
- deoiled lecithin powder / granules - 2% oil
- fractions - PC enriched / isolated
  - PC depleted
- enzymatic hydrolysed
- hydroxylated *
- acetylated*

* No E-number in Europe

Lecithin hydrolysis with enzyme



Degree of hydrolysis : 20 - 60 %, depending on requirement increasing hydrophilicity

Benefits for hydrolysis

- Formation hydrophilic Lyso-PLs
- Transformation “inactive” PE -→ functional LPE
- Improvement of Calcium –Resistance
- Effective processing aid – Oil Degumming
- LPL’s positive interactions:
  - Starch Amylose Complexation
  - Proteins – emulsion stability
  - Heat stable O/W and W/O emulsions

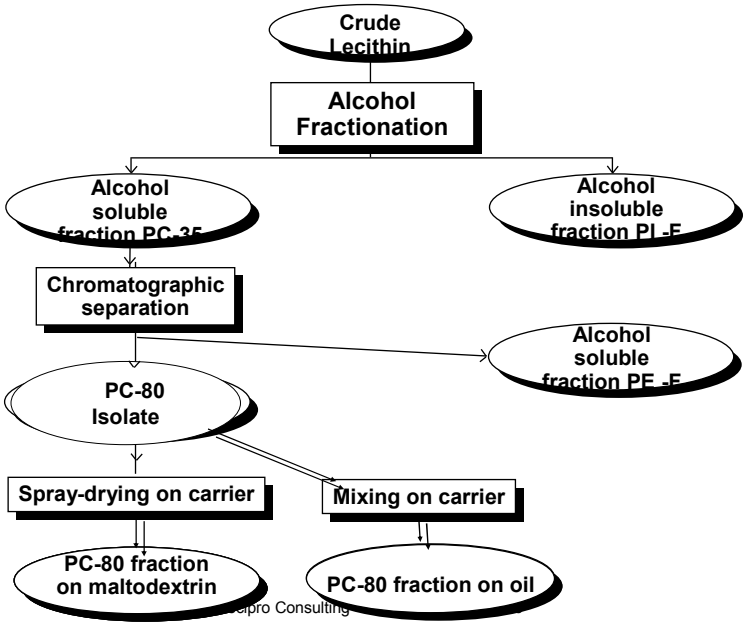
Fractionation techniques for phospholipid separation

- Alcohol fractionation
- Chromatographic isolation

Reasons for Fractionation

- Deoiled lecithins in powder and granule form with bland taste
- Specific surface-active properties, stabilizing emulsions
- Phosphatidylcholine (PC) forms liposomal bilayers with encapsulation capacity
- PC has specific nutritional and pharmaceutical properties

Lecithin fractionation process



PC/PE ratio in lecithin fractions

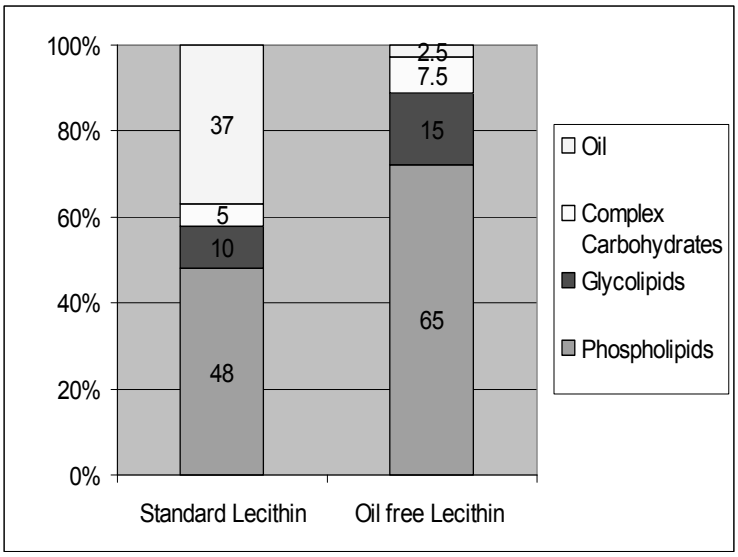
	PC	PE	PI	PC/PE ratio
Standard Lecithin	16	13	10	1.2
Alcohol soluble PC-35	35	8	1	4.5
Alcohol insoluble PI-F	5	14	12	0.4
PC-80 Isolate	80	3	-	25
Egg Lecithin	70	16	1	4.5

PC = phosphatidylcholine PE = phosphatidylethanolamine

Fractionation techniques for oil removal

- Acetone extraction
- Critical Carbondioxide extraction
- Near critical propane extraction
- Membrane technology

Composition of deoiled soy lecithin



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Required functions for emulsifier

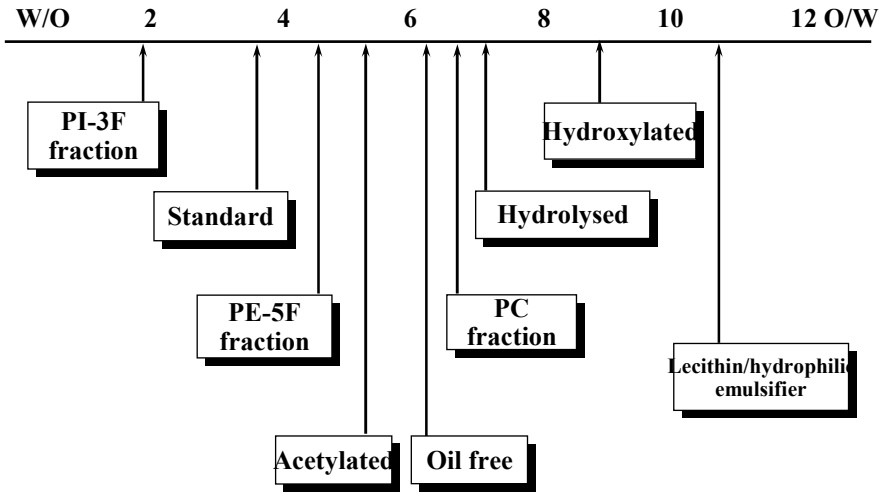
- Reduction of tension at Oil – Water interface
- Hydrophilic and Lipophilic Properties
- Good partial solubility in water and oil
- Facilitate disruption of bulk phases in small droplets
- Interaction with food ingredients may give unique added values
  - e.g. microbial shelf-life, mouth feel, melting behaviour, sensory, instant properties

Hydrophilic Lipophilic Balance (HLB) System

- Original classification system by Griffin (1949) for non-ionic emulsifiers – Spans & Tweens
- Other surface active substances can be compared in empirical emulsion tests
- Scientific “dangerous” , since selection of emulsifier can be wrong

HLB Range	Application
3-6	W/O emulsifier
7-9	Wetting agent
8-18	O/W emulsifier
13-15	Detergent
15-18	Solubilizer

Modified Lecithins : HLB range



Characterization tests of Lecithin Surface activity

- Dispersibility test — lecithin / water
- Emulsifying capacity test — lecithin / oil / water
- Emulsion stability test — lecithin / oil / protein / water

PARAMETERS :

- Mixing - Homogenisation (shear, time, energy)
- Solubility speed
- %Oil in O/W emulsion
- Stability (pH, protein, salt, Calcium)

INVESTIGATION VALUES :

- Creaming
- Sedimentation
- Particle Size Distribution (Malvern Zetasizer, Coulter)
- Electric Repulsion / Zeta potential

Rating of lecithin emulsifying performance

	Dispersibility	Emulsifying Capacity
Standard liquid	1	2
Standard oil-free	3	2
PC-35 fraction	3	4
Hydrolysed	4	5
Hydroxylated	5	5

1=poor 5=excellent

Test procedures: What do we learn?

1. Pre-selection tool in laboratory:
   1. Type emulsifier, oil, protein,
   2. Type of emulsion
   3. Effect of mixing and homogenisation
   4. pH, Temperature, Time, Water Hardness
   5. Estimate of required equipment

2. Translation to real recipe
   1. Application tests with final recipe
   2. Fine tuning of recipe and procedures

Phospholipid composition relevance for surface-activity

- Good dispersibility and transfer to interface of eminent importance
- Phospholipids determine surface activity→ →emulsifying functionality→ technological function
- Important PLs:
  - High PC, -Low PE, -Ratio PC / PE,
  - Lyso PL's →Hydrolysed lecithin
  - Electric loading (zwitter-ion)
  - Chemical modified PL's for non-food uses

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Foods: Colloidal Dispersions

liquid/ solid particles in continuous phase

PRODUCT	EMULSION TYPE	MAIN COMPONENTS
Fat spreads	W/O	water droplets and protein in semi-solid fat phase
Ice cream	O/W	fat in water phase + milk protein and starch
Mayonnaise	O/W	oil in water phase + egg yolk
Milk	O/W	fat + protein in water phase
Chocolate	W/O	dispersed sugar & cocoa particles in fat phase

Functionality of lecithin in foods

APPLICATION	FUNCTIONALITY	TYPES OF LECITHIN
↗Baked goods	Volume improvement Fat dispersion Anti-staling	Hydrolysed Deoiled Standard
↗ Chocolate	Viscosity modification	Standard
↗ Instant drinks dairy/cocoa	Wetting Dispersibility	Deoiled Fractions
↗ Margarine	Anti-Spattering Emulsification	PC fraction Hydrolysed
↗ Flavours	Encapsulation	PC fractions
↗ Release agents	Separation Wetting	Hydrolysed Special refined

Instant powders: Benefits of lecithin as instantizing & agglomeration agent

- Support Agglomeration process
- Promote controlled hydration of hydrophilic powders
- Rapid wetting of lipophilic powders
- Promote rapid wetting in hot and cold water
- Retain instant properties for extended periods
- Retain the flowability of the powder
- Lecithin is most used emulsifier

(Hydrolyzed) Lecithins in Bakery

- Bread Volume
- Crumb Softness (Shelf life)
- Dough Machinability
- Cake- & wafer Emulsification
- Release from hot baking surfaces

Summary Liposomal Encapsulation

- PC fractions construct liposome -bilayers
- Food grade liposome / nano emulsion system without solvents made with homogenisation
- Restricted (post) loading capacity of hydrophobic components
- Encapsulation of high value ingredients:
  - antioxidant efficiency improvement
  - controlled flavour release
  - targeted drug release

Summing up

- Phospholipid composition of standard lecithin is important
- Often used modifications are enzymatic hydrolysis, fractionation and deoiling.
- Modifications aim for specific emulsifying properties
- Emulsion tests: first screening of desired properties
- Methods of analysis are important for legal, commercial and technological reasons.

Future Trends

- PC Choline and PS health claims to be be further substantiated
  - Need for well controlled clinical tests at 1-2 years period,
- Pure PC fraction market for excipient use will grow
- Scope for PC fractions for liposomal encapsulation
- Challenge Enzyme modification of Phospholipids
  - Better emulsifiers
  - Interesterification of Omega fatty acids
  - PS
- Marine Ω and Dairy Phospholipids market launches
- Pharmaceutical / medical focus

Recommended Literature

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