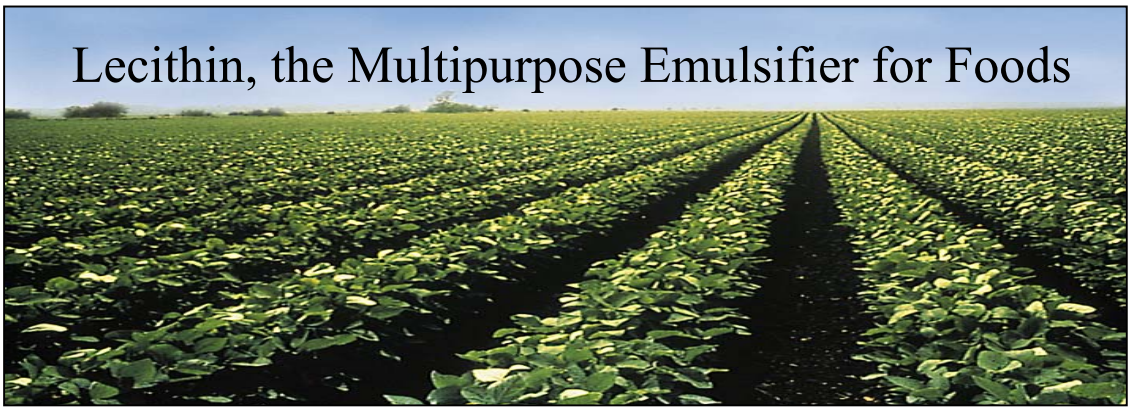
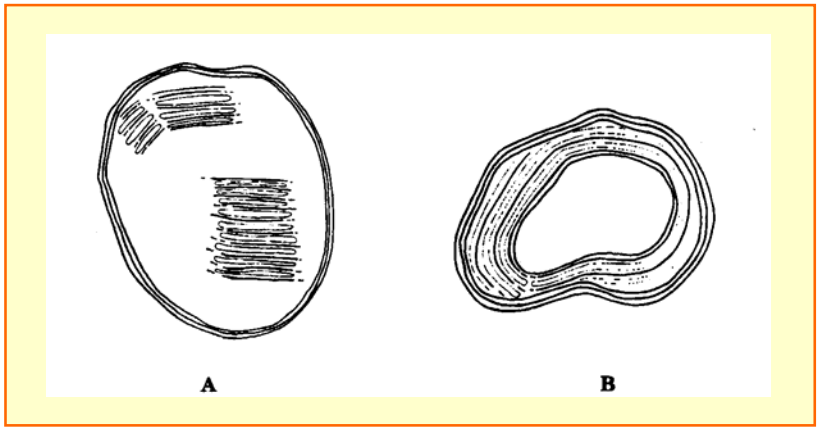


The adventure of Lecithin takes its beginning in living matter.
Lecithin is then extracted and used by mankind.
Finally Lecithin is returned to living matter again in a full circle.

The Occurrence in Living Matter

Phospholipids exist in all living species; plants, animals, fish and micro organisms. They are the major lipid component of most cell membranes where they serve both structural and functional purposes and interact with metabolites, ions, hormones and antibodies. Figure 1 is a diagram of the membrane structure of phospholipids in bacteria. The bundles of disc shaped vesicles in type A and the peripheral membranes in B, are characteristic to different species of bacteria. It is presumed that these structures contain essential enzymes for metabolism. In higher organisms more complex structures can be found by the use of electron microscopic techniques.

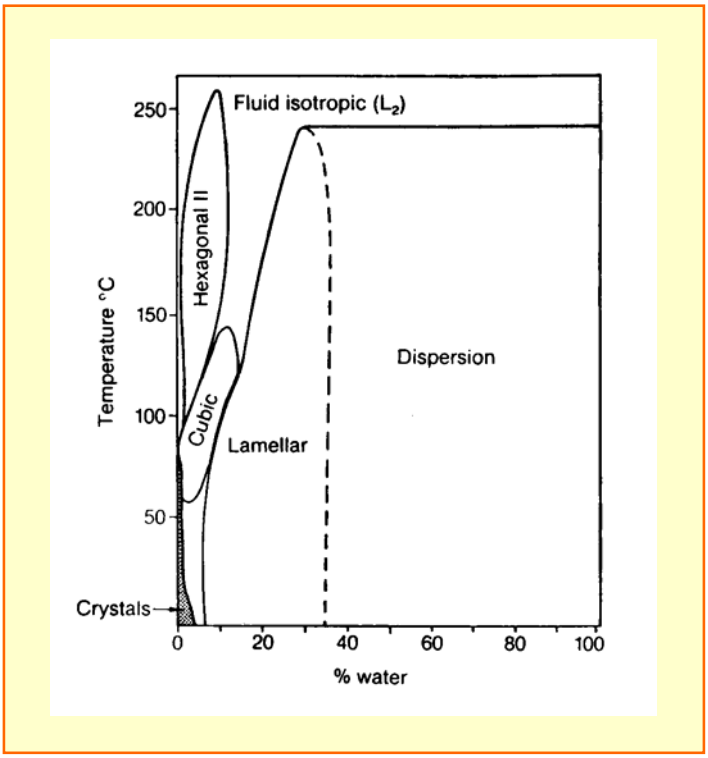


Lamellar Biological Structures [1]
Figure 1

The fundamental property of phospholipids is their unusual ability to swell in water and spontaneously form “liquid crystalline” structures. It is how nature build biological

membranes. It is the mechanism used in commercial lecithin manufacture and it is also the very reason why lecithins are like a workhorse to the food industry!

Figure 2 illustrates the behaviour of purified soya bean lecithin. Depending on temperature and concentration the liquid crystalline structures take distinct different three-dimensional forms.



Phase Diagram of Soybean Lecithin in Water [2]
Figure 2

Figure 3 visualizes the three dimensional structure of some of the liquid crystalline structures.

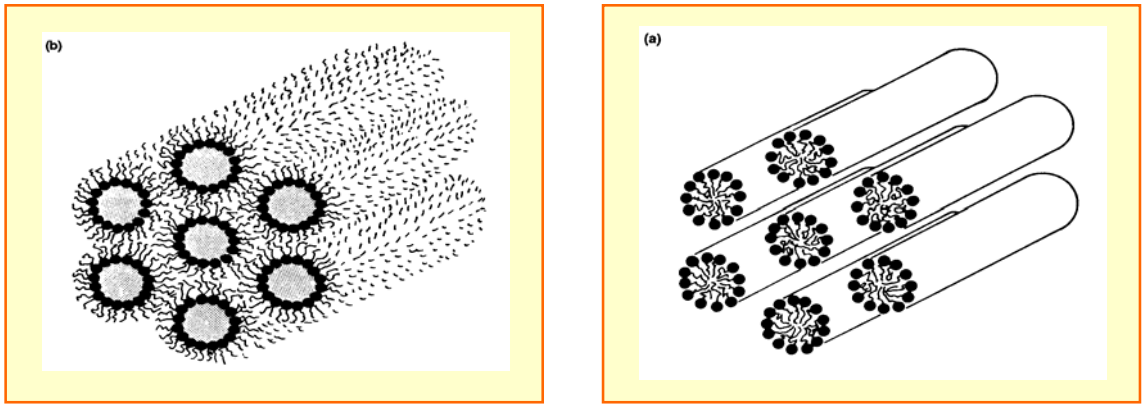


Diagram of Hexagonal Phases [3]
Figure 3A

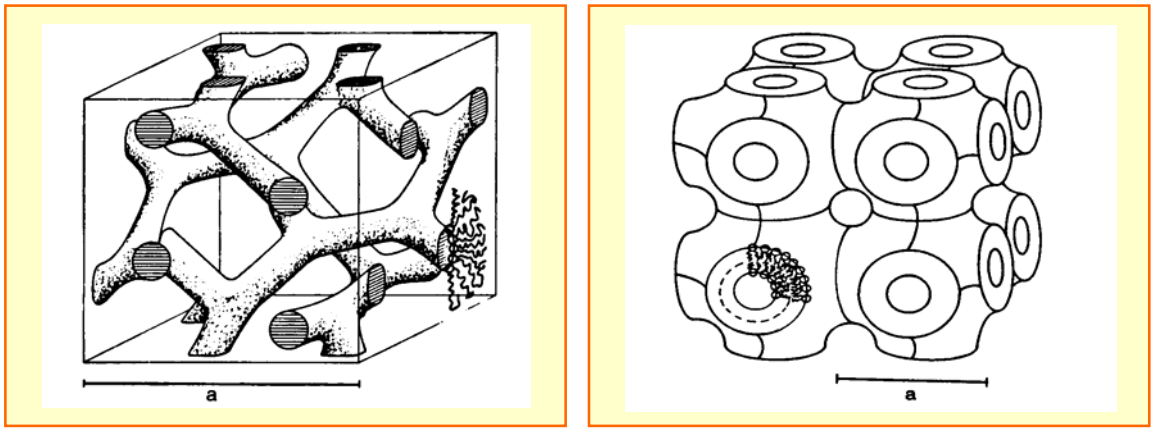
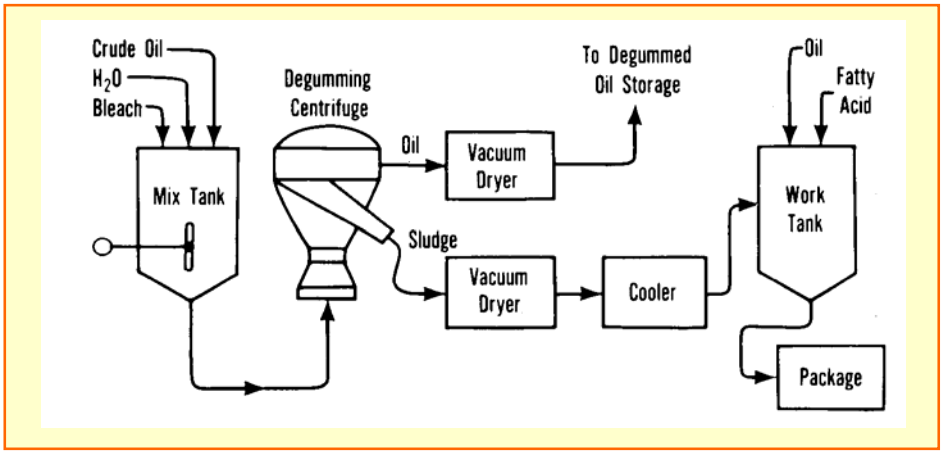


Diagram of Cubic Phases [3]
Figure 3B

The Extraction of Lecithin by Man

Lecithin occur at the rate of 0,5 % in the group of oil seeds. Since huge volumes of oil seeds are crushed beyond 200 million tonnes annually then the plant seeds become the primary commercial source of lecithin. During the crushing the cell walls are opened, enabling to extract the oil. A part of the phospholipids remains bound to the cell walls, while another part of the oil-soluble phospholipids simply "follows" the vegetable oil after pressing or extraction, but it must be removed from the vegetable oils in order to make quality edible oils. Figure 4 shows a typical production system for lecithin manufacturing.



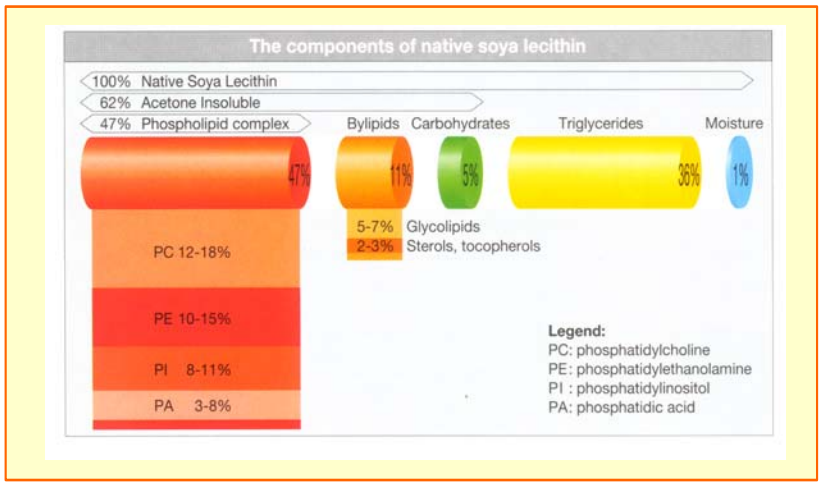
Batch Degumming System for Lecithin Production [4]
Figure 4

Lecithins are mixtures or fractions of phospholipids obtained by physical procedures from animal or vegetable food stuff (definition E322)

Although lecithin is oil-soluble it also has an affinity to water. When water is added at about 2 % to crude oil at 70 ° C (figure 4), the phospholipids hydrates and form gels. The gels swell, become insoluble and precipitate from the oil over a period of 15-30 minutes. The gums or lecithin sludge can then be removed by centrifugation. This is referred to as the degumming step in oil refining. The water content in the gum is 25 % or more and needs to be removed quickly in order to avoid microbial spoilage. Thus the food usage of lecithins require investing often 2 mm€ in a thin film evaporator. These "dryers" flashes off the moisture under vacuum in 1-2 minutes at temperatures of 90-100 ° C. Lecithin is very sensitive to heat and after the drying the product must be cooled immediately, preferably under 50 ° C.

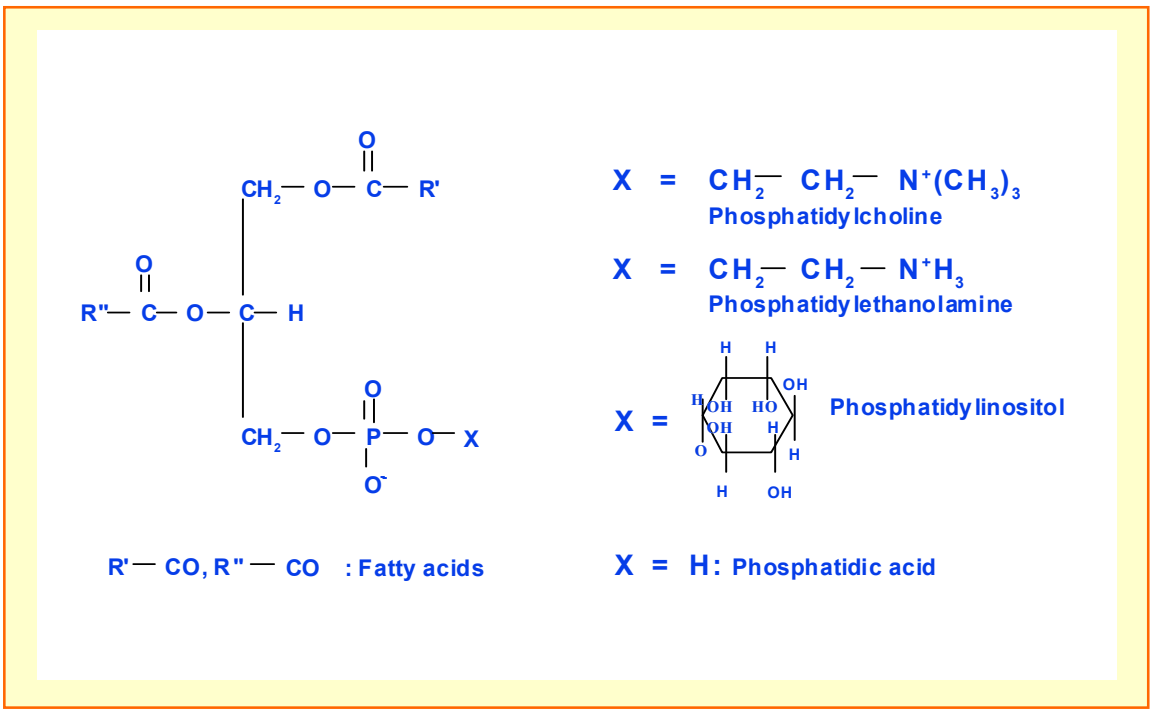
Thus lecithin is simply a natural resource like the "Food Ingredients" sugar, fat, protein and starches – but historically lecithin has been considered as a "Food Additive" classified as E 322 in the group of Antioxidants! The "Man-made emulsifiers" are actually in the emulsifier group E-number 400'reds. However there is a need to standardise the level of phospholipids in lecithins. Phospholipids are not soluble in acetone and standard fluid lecithin must conform to a minimum of 60 % "Acetone Insoluble". The phospholipids and the embedded oil are entirely soluble in toluene and lecithin must also conform to a maximum of 0,3 % "Toluene Insoluble" as a measure for impurities.

Figure 5 shows the typical composition of lecithin components. There are several types of Phospholipids frequently referred to as PC, PE, PI and PA.



Main Components of Native Lecithin
Figure 5

Figure 6 explains the chemical differences between the different phospholipids.



Chemical Structure of Phospholipids
Figure 6

The various phospholipids behave different when suspended in water and figure 7 is a good indicator that one should expect different functional properties in practice of the different phospholipid isomers.

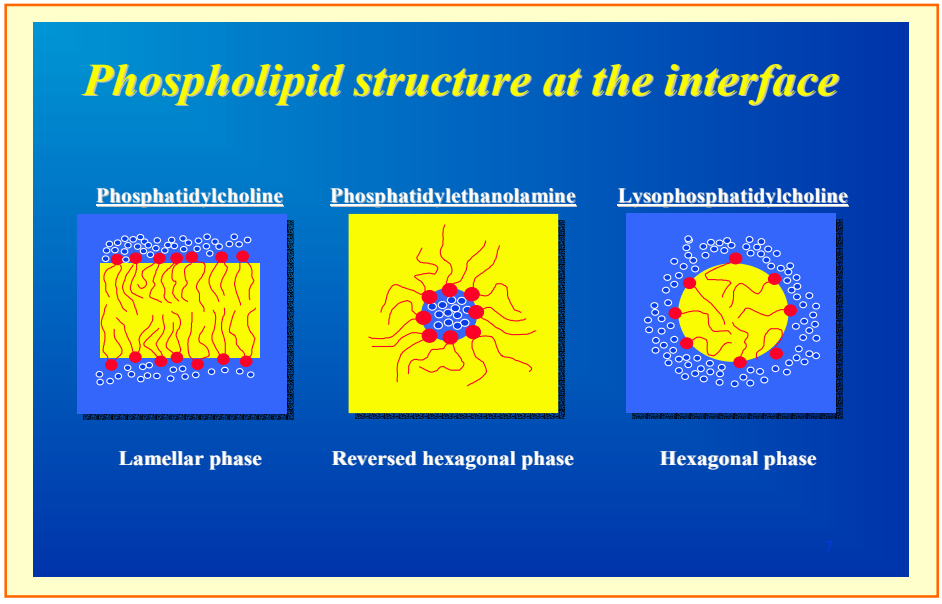
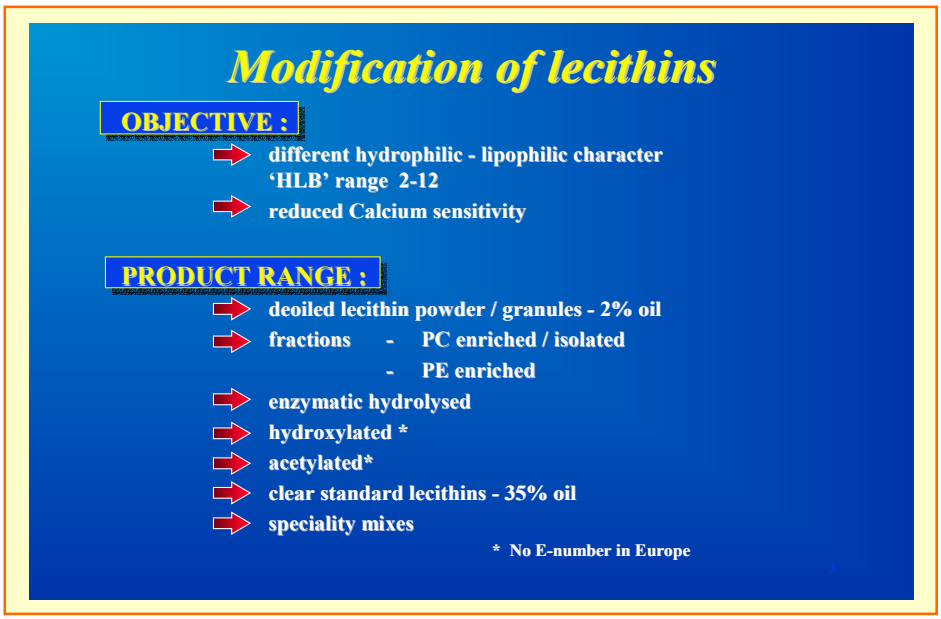


Figure 7 Spontaneous Phospholipid Structures in Water

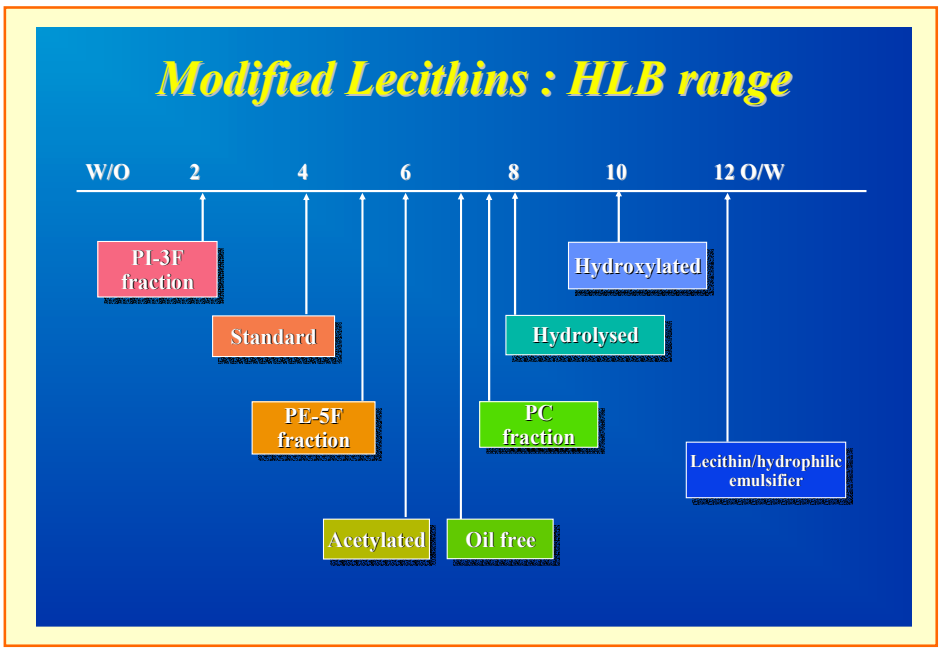
The Practical Use of Lecithin by Man

It is exceptional among emulsifiers that one category, E 322 contains *very different types* of lecithin. According to the definition of E 322 lecithins "are mixtures or fractions of phospholipids obtained by physical procedures from animal or vegetable food stuffs – they also include the hydrolysed products obtained through the use of harmless and appropriate enzymes". Historically hydrolysed lecithins were maintained within E 322, because they occur in nature. Figure 8 lists some of the possibilities for physical and chemical production methods for "processed lecithins".



Physical and Chemical Production Methods for Lecithins
Figure 8

The important objective for making the different types of lecithins is to alter the functionality of the lecithin in various foods. Figure 9 is the simplest "picture" that visualises the different properties of lecithins. Hydrophilic-Lipophilic-Balance-Values are only valid for simplistic model systems of surfactant in water/oil and most food applications are indeed much more complicated.



HLB Values of Lecithins
Figure 9

Concluding, lecithins have both affinities to oils and to water – they are "surfactants", and this is the basis for *all commercial applications* in foods such as margarine, chocolate, bakery and instant products etc. Fundamentally, the functionality of lecithin is a matter of their surfactant- or emulsification properties.

The Return of Lecithin to Living Matter

Lecithins continue to enjoy a strong consumer acceptance since they are simply extracted from their natural sources. When the phospholipids are consumed in adequate quantities they offer several well documented health benefits such as brain and liver function, cardiovascular health and reproductive development. The key to these benefits is the content of **Phosphatidylcholine**, the bio-active choline bound together with essential fatty acids. Since September 2001 the FDA is recognising **choline** as an essential nutrient and the National Academy of Sciences' has earlier issued Adequate Daily Intakes of choline depending on population segment. One of the very large food applications of granulated or deoiled lecithin is actually as a dietary supplement – simply a spoonful a day sprinkled on breakfast cereals or yoghurt.

Whether lecithin is used as dietary supplement or for foods, they are indeed returned to life where they came from completing the Adventurous Circle of Lecithins…

The Gift from Nature: Fluid- and Deoiled Lecithin's

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4) Lecithins, Sources, Manufacture & Uses, B. Szuhaj, American Oil Chemists' Society, Champaign, Illinois, 1989; "Commercial Manufacture of lecithin", G. List, US Department of Agriculture, p 148