

# Lecithin Production and Utilization

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## ABSTRACT

Commercial lecithin is the most important byproduct of the edible oil processing industry because of its functionality and wide application in food systems and industrial utility. The recovery of lecithin from oil is a relatively simple process. Hydration of the phosphatides by water or steam followed by recovery by centrifuge and drying is all that is required. But in order to maximize lecithin's utility and functionality, processing conditions all the way back to the bean or seed must be carefully controlled. Bean storage and handling, crude oil storage, refining pretreats, drying processes, bleaching, chemical modification, and storage all can affect lecithin quality and performance. The effects of processing on lecithin quality and performance is one of the major focal points in this presentation. Utilization of lecithins has expanded beyond the traditional application in paints, chocolate, and margarine. Food technologists have used lecithin as a functional ingredient in many modern systems. Its multifunctional properties and its "natural" status make commercial lecithin an ideal food ingredient. The major functional properties include: emulsification, instantizing and particle wetting, release, viscosity modification and nutrition. The nutritional impact of lecithin is currently being assessed in the medical field as an important factor in improving neurochemical disorders. Other medical and health related activity areas include positive changes in cholesterol, blood chemistry and circulatory factors. Lecithin is also used in numerous industrial and nonfood applications such as pigment dispersing, mold release, and animal feeds. The major source of commercial lecithin is from the processing of soybean oil. Evaluation of lecithins from other seed crops such as cotton, corn, and rapeseed is being pursued. The growth of these sources will be a function of demand.

## AN INTRODUCTION TO LECITHIN

Commercial lecithin, because of its multifunctionality and wide applicability sells for 2-10 times the price of soybean oil. It has more functional value than tocopherols, sterols, or fatty acids.

### Definition

Commercial soybean lecithin is a complex mixture of phosphatides, triglycerides, phytoglycolipids, phytosterols, tocopherols, and fatty acids. In this paper, the term "lecithin" will be used to denote commercial soybean lecithin, rather than chemical lecithin, phosphatidylcholine.

### Availability

Crude soybean oil is the principal source of crude lecithin. The potential volume based on total soybean production is nearly 250,000,000 lb. About 2/3 of this is recovered for commercial use. It is estimated that there are more than 75,000 metric tons of lecithin available worldwide. About 45% of that amount is manufactured and used in the USA.

### Sources

As mentioned before, soybeans provide the major volume of usable commercial lecithin. Lecithin may be obtained from other plant seeds such as corn, cotton, peanuts, and sunflowers, but little or none is available for commercial or industrial use (1).

### Composition

Soybean lecithin contains phosphatides, phytoglycolipids, triglycerides, phytosterols, tocopherols and free fatty acids. Phosphatides are the major functional ingredient in soy-

bean lecithin. A typical phospholipid composition for a crude lecithin is: phosphatidylcholine (PC), 15%; phosphatidylethanolamine (PE), 13%; phosphatidylinositol (PI), 9%; phosphatidic acid (PA), 5%; and phosphatidylserine (PS), 2%.

The ratio of these phospholipids is important for functionality. For example, high PC favors oil-in-water (o/w) emulsions, whereas high PI favors water-in-oil (w/o). Processing factors, either deliberate or unintentional, can affect lecithin's performance as an emulsifier.

## MANUFACTURING CRUDE LECITHIN

The process for obtaining lecithin from crude vegetable oils is simple and straightforward. The primary method (Fig. 1) for obtaining lecithin is by degumming crude oil where up to 3% steam or water is added to crude oil with slow agitation to hydrate the lecithin. These hydrated gums are then removed by continuous centrifugation. The resulting wet gums are dried either through batch or film drying.

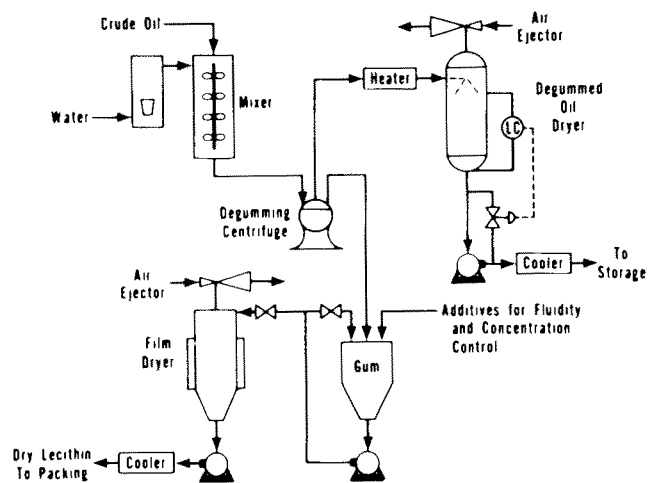


FIG. 1. Flow diagram of soy lecithin degumming (2).

As you can see from Figure 1, a very important part of the process is needed to maintain consistent quality and uniformity; this is the additive step. Fluidizing additives such as soybean oil, fatty acids, or calcium chloride can be added to "adjust" the viscosity and acetone insolubles. If this process is not carried out, the end product, on cooling, will be a highly plastic solid. Plastic lecithin is usable and functional, but is not convenient for most end users because it requires heating and mixing to fluidize the crude lecithin.

The National Soybean Processors Association has published, as shown in Table I, specifications for commercial soybean lecithin in their Yearbook and Trading Rules. These six grades are the most widely manufactured, but are only about 1/6th of the products sold today. These six grades cover the basic fluid and plastic grades with standard color ranges. The fluidity and color are adjusted before the hydrated lecithin gums are dried. Note the uniform acetone

## LECITHIN PRODUCTION AND UTILIZATION

**TABLE I**  
**Soybean Lecithin Specifications (3)**

Grade:	Fluid natural lecithin	Fluid bleached lecithin	Fluid double-bleached lecithin
<b>Analysis</b>			
Acetone insoluble, min	62%	62%	62%
Moisture, max <sup>a</sup>	1%	1%	1%
Benzene insoluble, max	0.3%	0.3%	0.3%
Acid value, max	32	32	32
Color, Gardner, max <sup>b</sup>	10	7	4
Viscosity, poise, @ 77 F, max <sup>c</sup>	150	150	150
Grade:	Plastic natural lecithin	Plastic bleached lecithin	Plastic double-bleached lecithin
<b>Analysis</b>			
Acetone insoluble, min	65%	65%	65%
Moisture, max <sup>a</sup>	1%	1%	1%
Benzene insoluble, max	0.3%	0.3%	0.3%
Acid value, max	30	30	30
Color, Gardner, max <sup>b</sup>	10	7	4
Penetration, max <sup>d</sup>	22 mm	22 mm	22 mm

<sup>a</sup>By toluene distillation for 2 hr or less (AOCS Method Ja 2-46).

<sup>b</sup>On a 5% solution in mineral oil.

<sup>c</sup>By any appropriate conventional viscosimeter, or by AOCS Bubble/Time Method Tq 1A-64, assuming density to be unity. Fluid lecithin having a viscosity less than 75 poise may be considered a premium grade.

<sup>d</sup>Using Precision cone 73525, Penetrometer 73510; sample conditioned 24 hr at 77 F.

insolubles, moisture, benzene insolubles, acid value, viscosity, and penetration, along with their different Gardner colors.

#### Six Categories of Upgraded Lecithin Products

**Clarified lecithins.** These have been carefully filtered in: (a) the full miscella; (b) crude oil; or (c) directly as lecithin. This filtration is carried out on plate and frame filters with manual or automatic cleaning cycles.

**Fluidized lecithins.** These are made by calcium chloride addition to the gums; addition of fatty acids and vegetable oil; or the addition of special proprietary diluents.

**Compounded lecithins.** These are special purpose products made by direct addition of functional food additives like Spans, Tweens, or by the addition of industrial surface active agents. Deoiled lecithin may be combined with selected additives to improve handling and performance.

**Hydroxylated lecithin.** This is a highly water dispersible lecithin made by reaction of hydrogen peroxide and lecithin in the presence of a weak acid like lactic or acetic acid. These mildly modified lecithins have a high rate of functionality in water-based systems. The color is extremely light, but the flavor tends to be soapy.

**Deoiled lecithin.** This can be made by contacting the crude lecithin with warm acetone. The resulting dried product is a tan-colored, waxy solid that can be made to special particle sizes and have excellent free-flowing properties.

**Fractionated lecithin.** This is made by fractionating crude lecithin directly or after deoiling. Several patented processes use short-chain alcohols to split the lecithin into alcohol-soluble lecithin. These special products have functional properties that result from their particular phosphatide compositions.

#### MANUFACTURING/QUALITY IMPACT

Several factors before and after the simple degumming process have a major impact on lecithin quality and performance. Some of these are described below.

##### Growing Conditions

Even though the ratio between phosphatides and oil is fairly constant, the growing conditions can have an effect on the fatty acid composition of lecithin. Soybeans grown in northern latitudes have higher linolenic acid content than those grown in warmer climates. Cooler summers tend to reduce the levels of unsaturated fatty acids.

Soil composition affects the ratio of oil to meal protein and the trace mineral content of lecithin. For example, beans grown in the Southeastern USA have a higher calcium content than Northern beans.

##### Harvesting Time

Harvest time is usually affected by spring planting conditions and early frost. Wet spring weather delays planting in some areas, resulting in premature harvesting. Green immature beans not only affect lecithin color, but also the amount and composition of the phosphatides.

Privett has shown that beans 67 days after flowering have higher amounts of phosphatidic acid and lower phosphatidylcholine. The difference in phosphatide composition between 67 days and 97 days after flowering is a 3-fold increase in phosphatidylcholine and a 7-fold increase in phosphatidylethanolamine. The oil content is essentially unchanged.

Frost-damaged beans can result in lower phosphatide yields and higher free fatty acids. This situation will lead to lower acetone insolubles (AI) and different gum consistency that affects degumming centrifuge efficiency and lower vis-

cosity lecithin products. The AI can go from percentage in the mid 70s to the low 60s. This results in lecithin products that are harder to adjust for AI and acid value. The oxidative stability of the oil and lecithin from frost-damaged beans is also reduced.

#### Bean Storage

Soybeans, like all other seeds, are living systems. Bean composition does change with age and storage condition. With the change or trend from in-plant silo storage to on-the-farm storage, beans can be 1-2 years old before processing. The extended storage situation can change the AI content of the oil. Old beans tend to have higher phosphatidic acid and free fatty acid levels. These changes reduce viscosity and acetone solubles.

Frost-damaged beans have higher chlorophyll content and lower phosphatide content, whereas older beans have lower phosphatide, but higher phosphatidic acid and free fatty acid levels.

Silo-stored beans tend to be the best beans, if properly rotated and kept at low moisture. Beans stored in bean bowls or outside storage usually end up with heat damage from spontaneous heating in piles, while water leakage causes spoilage or fermentation. Hot spots can develop that burn the beans. Burnt or sour odors are transferred to the lecithin gums. This situation has little measurable effect on oil content, but it does affect lecithin yields.

Split beans have an adverse effect on both lecithin and oil quality. Once the hull is broken, exposure to light and heat will induce oxidation and decomposition of lecithin. Splits must be carefully added to the extractor to reduce further changes.

#### Extraction of Crude Oil

Modern extraction techniques are well documented for soybeans. Countercurrent solvent extraction can result in poor lecithin quality if the desolventizing temperature is too high and the oil is not properly cooled after the desolventizing process. Moderate temperatures and short exposure time are required.

Expeller oils tend to yield inferior lecithin. Low press temperatures are hard to maintain. This results in scorched lecithin and dark colors that are not bleachable.

#### Crude Oil Storage

The best way to store extracted soybean oil is in the crude state. The lecithin and tocopherols help maintain its oxidative stability. However, the lecithin quality can be affected if the crude oil storage tanks are overheated and the bottoms allowed to sour. Temperatures of 43-48 C, or even ambient are ideal for both the oil and lecithin. The longer the storage, the lower the oil temperature should be maintained. Agitation without aeration is the best way to eliminate lecithin settling. Simply turning the bottom is helpful.

#### Degumming Conditions

The oil refinery process dictates the type of degumming required. Steam or water degumming is ideal for a good high quality lecithin: 1-3% is optimum. Most additives used to aid degumming are usually deleterious to the lecithin, except for acetic anhydride. Acetic anhydride will react with the lecithin gums to form some acylated phosphatidylethanolamine. Other additives such as phosphoric acid tend to burn the lecithin on drying. Oxalic acid renders the lecithin toxic. Inorganic salts affect the physical and functional properties.

#### Wet Gum Storage

Since the gum lecithins are usually collected over several

hours, dilute hydrogen peroxide is added to stabilize the wet gums from bacterial spoilage. The type of bacterial growth reflects the environment of the processing plant. Coliforms must be eliminated by using good manufacturing practice.

#### Bleaching/Color Control

Better processing controls and bean storage and handling have reduced the degree of bleaching required to control lecithin color.

Hydrogen peroxide (3%) is used up to 1.5% to obtain a single bleached Gardner color of 14 minus. Benzoyl peroxide up to 1.5% can be used to obtain a double bleached color of 12 minus. Each peroxide affects a different color body system. Care must be observed in dose levels as the hydrogen peroxide reduces the brown pigments and benzoyl peroxide reduces the red pigments. In early beans, the green from chlorophyll can be unmasked by the benzoyl peroxide reducing the red pigments.

In bleached products, the elevated peroxide value indicates free peroxide. It should be noted that complete elimination of all peroxide at elevated temperatures (70 C) will cause the lecithin to darken rapidly.

#### Drying Lecithin

Batch drying was the most widely used method of drying lecithin. Because of the time lag needed to collect the gums, this system was the most logical approach. Lecithin is difficult to vacuum dry because the foaming must be controlled. This required careful monitoring of vacuum levels and long drying time: 3-4 hr.

Film drying has been more successful in measuring the drying rate and reducing the time and temperature exposure. A cooling loop is essential to prevent darkening. Also, film drying is more effective in removing residual acetic acid in modified products.

#### Storage and Handling

Once the lecithin product has been dried it must be stored in bulk or suitable sized containers such as 55 gallon drums. Bulk storage can be heated or ambient. If heated, the temperature must be controlled at ca. 48 C. Long times at elevated temperature will cause darkening. Drum storage and handling of lecithin products is most convenient. Shelf life of most lecithin products at 21 C is more than one year. However, physical stability can be affected by reduced temperatures around 0 C. Freezing or lecithin can lead to a separation of the oil phase. Simple remixing in the drum is usually adequate to redispense the phosphatides. The steel drum can be heated easily with a Band heater or steam coil to decrease the viscosity for easier pumping.

#### UTILIZATION OF LECITHIN

Commercial lecithin is used for its multifunctional properties which are: emulsifying; antispatter; instantizing/wetting/dispersing; release/parting agent; viscosity modifying; and, diet supplementing.

In the USA, lecithin is GRAS approved; kosher approved, and meets standards of the Food Chemicals Codex.

The above facts make lecithin products ideally suited for food applications. Being a natural product also gives lecithin an added advantage in today's markets demanding "non-chemical" additives. The consumer is very familiar with the word lecithin and rates it highly acceptable.

Lecithin is used as an ingredient in margarine, confections and snack foods, instant foods, commercial bakery products, cheese products, meat and poultry processing, dairy and imitation dairy products, and dietary supplements.

It is also used as a packaging aid; and directly on processing equipment as a lubricant.

#### Functions of Lecithin in Food Systems

- In margarine - lecithin is used for antispatter.
- In chocolates, caramels, and coatings - lecithin controls viscosity, reduces sticking, and controls crystallization.
- In instant foods such as cocoa powders, breakfast drinks, coffee whiteners, milk replacers, puddings, and toppings - lecithin functions as both an emulsifier and wetting agent.
- In bakery products such as breads, rolls, doughnuts, cakes, cookies, pastries, and pies - lecithin acts as an emulsifier, wetting, and release agent.
- In natural and imitation cheeses - lecithin is an effective emulsifier and slice parting agent.
- In meat and poultry glazes, pet foods, and bacon - lecithin is a good browning agent, emulsifier, phosphate dispersant, and dietary supplement.
- In dairy and imitation dairy products - lecithin is effective in infant milk formulas, milk replacers, egg replacers, whipped toppings, ice cream, and flavored products as an emulsifier, wetting agent, antispatter, and release agent.
- In spreads and salad products - lecithin acts as an emulsifier and controls crystallization.
- As a packaging aid - lecithin is used as a sealant and release agent.
- On processing equipment such as frying surfaces, extruders, conveyers, broilers, dryers, and blenders - lecithin is an effective lubricant and internal or external releasing agent.

Most use levels for the above applications vary between 0.1 and 2.0%, depending on the method of application or incorporation.

No discussion on food applications for lecithin would be complete without mentioning its dietary and health implica-

tions. Lecithin is consumed as a whole food in liquid, capsule, or granular form. The early 1950 interest in lecithin was as a cholesterol-lowering agent. No conclusive evidence has been found. Today's interest in lecithin is in the area of aging and memory.

Research work at the Massachusetts Institute of Technology has shown that lecithin is effective in reducing the symptoms of specific neurological disorders. The findings have led medical researchers into exploring the effects of lecithin and memory. Their findings over the next decade will prove most interesting.

#### Non-Food Utilization - Industrial Applications

- In cosmetics - as emulsifier and emollient in hair and make-up preparations, creams, and oils.
- In pharmaceuticals - as dietary supplements, emulsifying agent for injectables, and dispersant for vitamins.
- In coatings and paints - as a pigment dispersant.
- In plastics and rubber molding - as both a pigment dispersant and mold release agent.
- In the paper and ink industry - as wetting agent and pigment dispersant.
- Masonry and asphalt products - as emulsifier and wetting release agent.
- In metal processing - as lubricants in wire drawing, cutting processes, and metal rolling.
- In animal feeds - as both a functional and nutritional ingredient, as fat emulsifier and wetting aid in calf milk replacers, and in pet foods to replace eggs and provide shininess to the fur.

#### REFERENCES

1. Anon., JAOCS 58:779A (1981).
2. Brian, R., Ibid. 53:27 (1976).
3. National Soybean Processors Association, Yearbook and Trading Rules, 1981-82.