SYMPOSIUM: NEW PROCESSING OF FATS AND OILS

Presented at the AOCS 66th Annual Meeting

Dallas, Texas

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Soybean Lecithin Processing Unit Operations

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ABSTRACT

Chemical engineering unit operations used in the processing of crude soybean oil to lecithin are defined and discussed. The unit operations of fluid flow, centrifugal separation, filtration, and heat transfer are discussed as they relate to commercial plant design. The types of equipment available for these unit operations and the merits of some particular types are discussed. The flow of a typical commercial plant is shown with utility consumption estimates.

INTRODUCTION

"Lecithin," a term applied to certain compositions separated from crude vegetable oils, is actually a misnomer, since the commercial product is a mixture of several phosphatides, including chemical lecithin. Although commercial lecithin products can be made from a variety of vegetable oils, the only source of prepared commercial lecithin in the U.S. is soybean oil.

No exact figures are available on the quantity of lecithin produced in the U.S. It is estimated that production on a crude lecithin basis is ca. 80 million lb per year (D.W. Johnson, personal communication, 1975). Had all the soybean oil produced in the U.S. in 1972 been degummed, the crude soybean lecithin production would have approached ca. 222 million lb.

Table I shows that soy lecithin is a mixture of 3 principal phosphatides along with soybean oil and some carbohydrates, sterols, and moisture (1).

Lecithin, which is used for both industrial and food purposes, may be chemically modified or fractionated for a variety of products having the specific characteristics demanded by the various intended applications. This presentation deals with processing unit operations.

TABLE I

Approximate % Composition of Commercial Crude Soybean Lecithin

Phosphatidyl choline (chemical lecithin)	20
Phosphatidyl ethanolamine	20
Inositol phosphatides	20
Soybean oil	35
Sugars, sterols, and moisture	5

PROCESSING FLOW

The processing flow of a typical lecithin degumming plant is shown in Figure I. Crude oil is first hydrated with water and then pumped to centrifuges. The degummed oil is heated to provide the latent heat to evaporate the residual water, then spray dried, and cooled for storage.

Lecithin gums from centrifugal separation are supplied with fluidity and concentration additives in regulated amounts, then dried, cooled, and either stored or packed.

The major chemical engineering unit operations involved in crude lecithin production are fluid flow, centrifugal separation, filtration, and heat transfer.

Fluid Flow

The unit operation of fluid flow is found in various forms in a commercial plant. Miscellas have a viscosity of <1 centipoise. Lecithin has maximum viscosity at 2-3% moisture. The viscosity of the wet lecithin from separation equipment increases in the drying operation to >1 million centipoise from an original viscosity of 300,000 to 600,000 centipoise, then rapidly reduces to ca. 30,000 centipoise as the moisture content reaches 1%. The Hagen-Poisuelle formula can be used to calculate pressures required to pump the highly viscous lecithin. Piping runs of other fluid forms are designed according to standard techniques. Gear pumps are normally used to move all fluid forms of the oil and lecithin, and centrifugal pumps are used for miscella.

Centrifugal Separation

Soybean phosphatides hydrate when water is added to crude oil at a level of 1-2.5% used in commercial plants.

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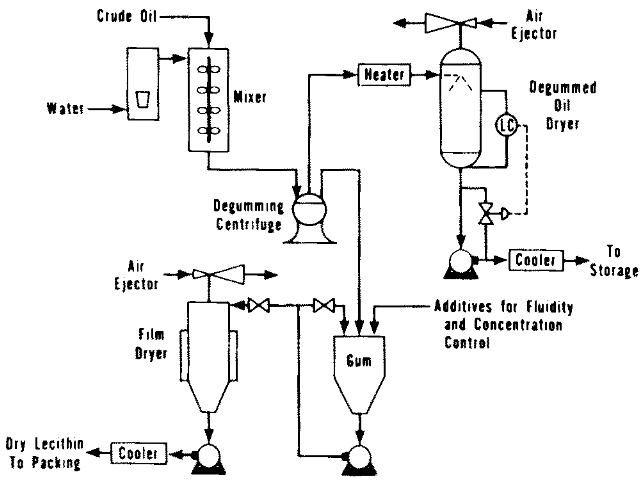

FIG. 1. Flow diagram of soya lecithin degumming.

The hydrated phosphatides, commonly called gums, are essentially oil insoluble and have a higher specific gravity than the oil. This combination of insolubility and higher specific gravity permits an easy separation of phosphatides and oil.

Centrifugal force applied to hydrated crude oil is recommended for this separation. Disc type, tubular bowl type, and parallel plate contactor type centrifuges are used. Disc machines can be either open discharge or hermetically sealed, or can use a centripetal pump to control discharge of fluids. Prominent factors affecting the efficiency of lecithin separation from crude oil in a centrifuge are centrifugal force, settling distances, and residence time in the centrifuge of fluids.

The disc machine affords medium centrifugal force, medium retention time, and minimum settling distances. The tubular bowl machine supplies maximum centrifugal force, minimum retention time, and maximum settling distances. The parallel plate contactor type machine furnishes minimum centrifugal force, maximum retention time, and medium settling distances.

For the highest practical concentration of lecithin from the centrifuge operation, the use of disc machines is normally recommended. The combination of adequate retention time, adequate centrifugal force, and least settling distance will normally yield the concentrations required.

Filtration

The crude oil used for lecithin manufacturing is usually filtered before degumming, although dry lecithin can also be filtered. Crude oil in miscella form can be filtered by at least 2 methods. One method employs a monofilament nylon or cotton muslin cloth stretched over metal frames in a liquid and vapor tight housing. This method does not require the addition of a filter aid to the miscella and removes enough meal fines to enable the production of a reasonably low solids content finished lecithin. The end product dry lecithin appears cloudy due to residual fines. Another method of miscella filtration involves the use of wire cloth filters. Filter leaves covered by a 60 mesh or 24 by 110 weave cloth retain the filter aid normally used to assist filtration.

Miscella concentrations and temperatures normally used are those of the miscella coming from the oil extractor. Filter aid addition at a rate of 0.05%, based on the wt of oil in the normal miscella from continuous extraction, is used to maintain a noncompressable cake. An area of cloth equal to 15 ft^2 per gal per min of crude oil is recommended for normal operations.

Crude oil is also filtered to produce clarified lecithin products from the oil. Dry oil needs to be heated to 180 F, 0.1% of filter aid added with agitation, and the mixture filtered. Historically, plate and frame presses have been used for this type of filtration. Press dressings vary widely, but 1 cloth found suitable is 10 oz cotton duck. An area of cloth equal to 40 ft^2 per gal per min of crude oil is recommended for normal operations.

Filtration of the dry fluid lecithin to produce a clear, brilliant product is possible. To accomplish this filtration, one can use a horizontal filter medium of cloth, add 0.4% filter aid to the agitated lecithin, and force the fluid through the filter medium. A fluid lecithin of 62% concentration can be expected to filter according to the following general equation:

$$V^2 = 650\,\theta \qquad \text{(I)}$$

Where: V = gal of filtrate
θ = time in min

Miscella filtration is the preferred method of clarifying oils that in turn produce clarified lecithins. For plants requiring the full production of clarified products, it is the most economical process.

Heat Transfer

Heat transfer to oil and lecithin is needed throughout lecithin processing. Crude oil may require heating or cooling from the storage or extraction processes to filtration or hydration. Degummed oil requires heating from the centrifugal separation prior to drying and is normally cooled before storage to facilitate loading operations. Shell and tube exchangers for heat transfer to oil are preferred with tube side velocities at 3-5 ft per sec. Overall heating coefficients are normally 50 BTU per hr per ft^2 per F, and overall cooling coefficients are 20 BTU per hr per ft^2 per F.

The transfer of heat to lecithin is required to evaporate the water from the gums and is normally used to cool the dried products prior to packaging. Among the several types of driers used are the so-called batch driers and film driers. A batch drier consists of a vertical jacketed tank with a close clearance agitator which continually moves the lecithin exposed to the heat transfer surface. The use of this type of drier was standard practice until the early 1950's when film driers were introduced for lecithin drying. Sizing this type of drier is done by experience, and heat transfer data is meager.

With film drying, colors of heat sensitive lecithin products were improved through equal bleaching additive treatments. While the drying operation results in much higher lecithin temperatures, they are for short times and the colors are better. Overall heat transfer coefficients of 100-150 BTU per hr per ft^2 per F can be expected in film drying lecithin, depending on the original gum moisture content and the concentration of the lecithin.

One means of cooling the dried lecithin is to circulate cooling water in the jacket of a batch drier. Another method sometimes used with film driers is to circulate lecithin in 1 channel and cooling water in the alternate channel of a spirally wound plate heat exchanger.

Since lecithin is a heat sensitive material, it preferably should be stored at temperatures below 140 F. However, short times at higher temperatures are permissable. The longer lecithin is held above 140 F, the more color it develops.

Utilities

The utilities required to process the crude oil from a solvent extraction plant handling 1,000 tons of soybeans per day are 550 kw per day of power, 150 gal per min of 85 F cooling water, and 900 lb per hr of steam.

Special lecithin products can be prepared by solvent extraction and/or chemical modification. The essentially complete removal of soybean oil by solvent extraction results in granular products. Crude soybean lecithin is the raw material of these products.

REFERENCES

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[Received June 12, 1975]