

Chapter 17

Soybean Oil Processing Byproducts and Their Utilization

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Introduction

Refining of soybean oil to make a neutral, bland-flavored, and light-colored oil results in several byproducts. Fig. 17.1 diagrams the conventional refining process and shows the byproducts that are generated at each stage.

In addition, waste oils are generated accidentally by spills and incidentally by operations such as cleaning equipment. Good practice dictates that these fatty materials be controlled at the source or recovered as saleable material to minimize waste treatment costs. Witte (1) discusses control of wastewater loads and estimates treatment costs at \$0.20/lb (\$0.44/kg) of oil or \$0.10/lb (\$0.22/kg) of organic material in water measured as biochemical oxygen demand (BOD).

These byproducts consist of various mixtures of phosphatides, unsaponifiables, glycerides, free fatty acids, and soap. The amounts of these materials present in the crude and refined oil are illustrated in Table 17.1 (2). The value of each byproduct depends on its composition.

Lecithin contains mostly hydratable phosphatides together with some free fatty acids and neutral oil (glycerides). It is used, in various modifications, for many food and industrial purposes. The amount recovered by water degumming varies depending upon the oil quality but will usually be 2.5 to 3.0% of the crude soybean oil degummed. Lecithin processing and utilization are covered in detail in Chapter 10.

Soapstock, or *refining byproduct lipids*, consists of soap, neutral oil, phosphatides, and some unsaponifiables. It is valuable as an animal feed additive and as a source of fatty acids for soap and oleochemicals. The amount of soapstock will vary depending on the quality of the crude oil and whether or not the oil is degummed before refining. The amount of soapstock recovered, as measured by Total Fatty Acid (TFA), may be less than 1% for high-quality degummed oil or may be very much higher for poor-quality oil or nondegummed oil.

If oil is physically refined rather than caustic-refined, no soapstock is generated. Instead, the fatty acids are recovered as distillate in the final physical refining.

Spent bleaching clay is not generally considered a byproduct, and much is simply disposed of in a landfill. However, it contains 20 to 45% oil, which can be utilized. In addition to recovering the value of the oil, processing the clay reduces fire hazards and pollution. Although various practices have been used over the years, growing environmental concerns have increased emphasis on finding improved methods of disposal and utilization.

Deodorizer distillate amounts to about 0.25 to 0.50% of the feed to the deodorizer. It consists primarily of unsaponifiables plus some fatty acids. It is valuable as a source of tocopherols and sterols, which are raw materials for vitamin E and pharmaceuticals (3,4).

Refining Byproduct Lipid (Soapstock)

Soapstock is the traditional name for the byproduct resulting from caustic refining of soybean and other oils. In 1992 the NOPA (National Oilseed Processors Association) *Trading Rules* (5) were changed to substitute the name *refining byproduct lipid* for *soapstock* to relate more closely to the Association of American Feed Control Officials (AAFCO) definition of a feed ingredient. This change reflects the impor-

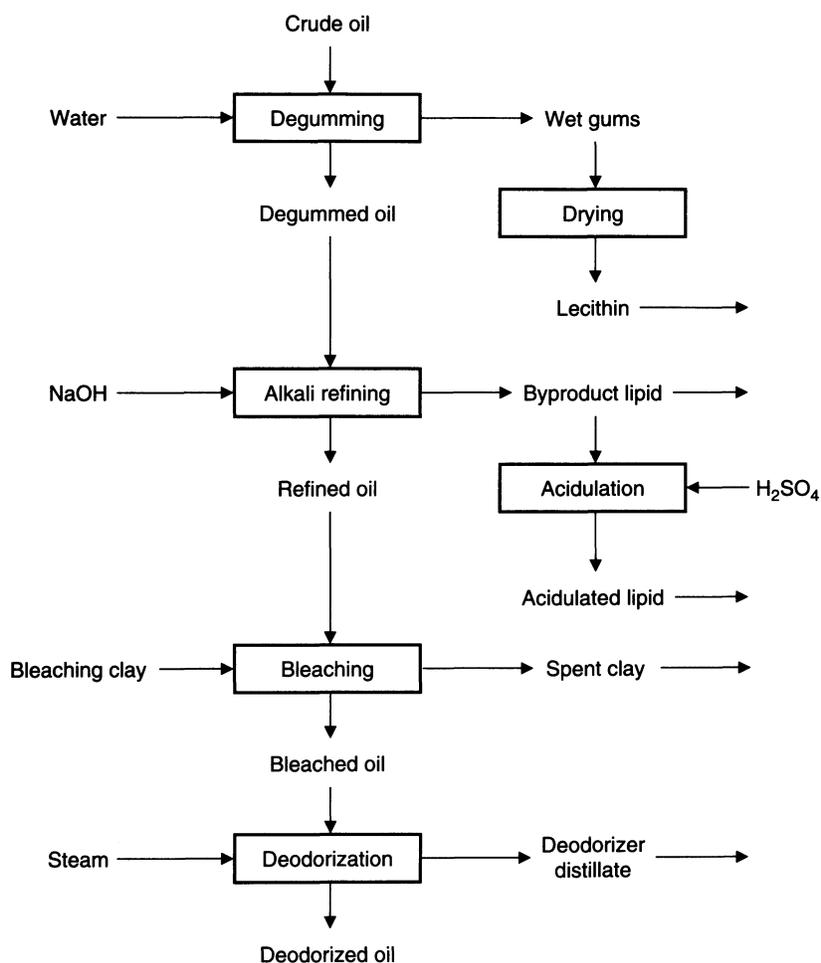


Fig. 17.1. Processing diagram for soybean oil.

tance of the product as an animal feed ingredient. In this chapter both terms are used depending on context.

NOPA contract rules specify that the “product must not be adulterated with any other oil or refining byproduct lipid made therefrom without consent of the purchaser, and nature and amount of the same must be declared in the contract” (5). This provision is significant, because soapstock from other oils may differ in properties essential to the buyer. For example, cottonseed oil derivatives are not used in poultry feed, because of concerns about gossypol, and the oleochemical industry may require raw materials with a defined fatty acid content.

The price of the raw product directly from refining is based on 50% total fatty acid (TFA) content, and the product is not merchantable if less than 30% TFA. The price of an acidulated product is based on 95% TFA, and it is not merchantable below 85% TFA.

Degumming is not essential for the refining process, and it is common practice for many processors to refine crude soybean oil without degumming (2). Soapstock from refining nondegummed oil is much greater in quantity than that from degummed oil and has a higher content of phosphatides, which would have been removed in degumming. The higher levels of phosphatides complicate acidulation and subsequent wastewater treatment.

Crude soybean byproduct lipids consist of soaps of soybean fatty acids, triglycerides, phosphatides, and degradation products as well as small amounts of sterols, tocopherols, pigments, proteins, and carbohydrates. The exact composition will depend on the composition of the feed to the refining process and refining conditions. Refining conditions are adjusted to remove free fatty acids and phosphatides with minimum hydrolysis or removal of neutral oil. Good practice is to keep the refining loss to less than 0.5% above the neutral oil loss (NOL) (6); see Chapter 11.

The principal material of value is the soybean fatty acids which are present in the form of soaps, triglycerides, and phosphatides.

Raw soapstock is difficult to handle. It solidifies readily when cooled and heated tanks and lines are necessary to maintain the temperature above 60°C. On standing, it may separate into two phases. If heated to boiling, it has a tendency to foam, especially if high in phosphatides. It contains large amounts of water and organic compounds and ferments readily unless maintained at a high temperature or treated with a preservative.

TABLE 17.1 Average Compositions for Crude and Refined Soybean Oil (2)

Average composition (%)	Crude oil	Refined oil
Triglycerides	95–97	>99
Phosphatides	1.5–2.5	0.003–0.045
Unaponifiable matter	1.6	0.3
Plant sterols	0.33	0.13
Tocopherols	0.15–0.21	0.11–0.18
Hydrocarbons (squalene)	0.014	0.01
Free fatty acids	0.3–0.7	<0.05
Trace metals (ppm)		
Iron	1–3	0.1–0.3
Copper	0.03–0.05	0.02–0.06

To reduce weight and stabilize the product for storing and handling, raw soapstock is commonly acidulated with sulfuric acid. Traditionally, soapstock acidulation has been done in a batch process, where soapstock is charged to a corrosion-resistant tank. Wooden tanks fitted with copper or bronze coils are still used, although more recent installations are likely to be *monel metal*, *Carpenter 20 CB*, stainless steel, or fiberglass-reinforced plastic (7,8,9). Typically, sulfuric acid diluted to *ca.* 10% is added in excess to the soapstock charge and the mass is boiled with sparge steam for 2 to 4 h. The tank is then settled, and the acid water layer drawn off. The acid oil is water-washed by adding 25 to 50% water, boiling for a short time, and settling thoroughly. After the water layer is drawn off, the acidulated soapstock will be stored or shipped in steel tanks. Detailed practices may vary considerably from plant to plant and even from charge to charge.

Continuous Acidulation

Several processes have been developed for continuous acidulation of soapstock. One such process (Fig. 17.2) that is currently being practiced on soapstock from degummed soybean oil has been patented by Bloomberg and Hutchins (10).

A mixture of soapstock and centrifuge flush water is delivered at a controlled rate into an acidulation vessel, together with a metered stream of sulfuric acid, to bring the pH to 1.5 to 2.0. The vessel is designed so that the contents are both mixed and heated with sparge steam to approximately 90°C. The mixture constantly overflows into a settling basin. In the settling basin the acid oil floats to the top and the acid water settles to the bottom. A series of valves at different levels are provided for drawing off the acid oil. The acid water overflows through a standpipe, which maintains the level in the settling basin. This process has been in successful use for several years. It is limited to use on soapstock from oil that has been thoroughly degummed, before even small amounts of gums create emulsions that will not separate.

De Smet (Brussels, Belgium) offers a process (Fig. 17.3) that is made continuous by providing three reactor tanks in parallel. Each tank is charged successively. The sequence of acidulation, water washing, and decanting is performed in each vessel. The acid layer from one vessel may be mixed into the soapstock charged to the next vessel to economize on acid usage.

The continuous acidulation process (11) described by Braae (Fig. 17.4) removes the bulk of the acid water by decanting. Wash water is added to the acid oil, and the water and solids are removed by centrifuging in a self-cleaning separator. The use of a surfactant, ethylhydroxyethylcellulose (50 to 100 ppm), to break emulsions is also described.

Another continuous acidulation process has been described by Crauer (12). In this process, continuous centrifuging is used to separate the acid water and acid oil. It is claimed that this reduces the fat content of the acid water to less than 0.4%, and the acid water stream is improved over the batch process in having a higher pH and lower fat and BOD content. A further process step, to neutralize the acid water continuously with lime and clarify it centrifugally, is said to reduce the BOD by 62 to 76% and to remove 80 to 95% of invert sugars and all of the fat.

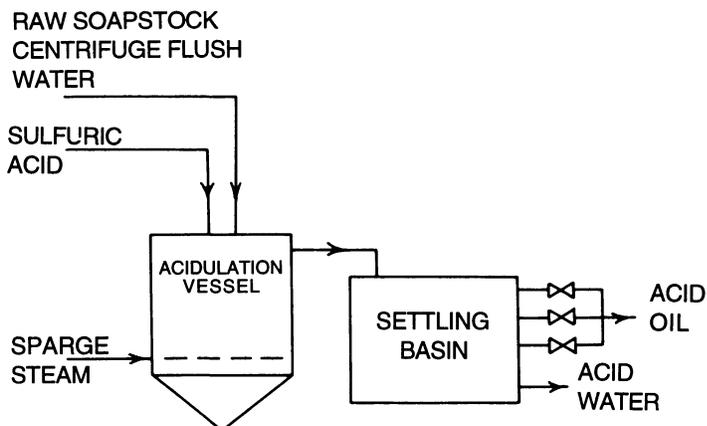


Fig. 17.2. Continuous acidulation of degummed soy oil soapstock. *Source:* Woerfel, J.B., *J. Amer. Oil Chem. Soc.* 60(2): 310 (1983).

Morren describes continuous acidulation (13,14), as shown here in Fig. 17.5 using a Podbielniak centrifuge. The residual TFA in the acid water is reported as 0.03 to 0.74% for different types of oils.

The use of centrifuges for separating acid oil from acid water in continuous soapstock systems has not been widely accepted in the United States, apparently because of the expense of the equipment and the severe corrosion problems inherent in the process.

A particularly interesting development was described by Mag et al. (15) and is shown in Fig. 17.6. In this work, they adopted a practice from petroleum oil/water separation technology. After decanting, the acid water is passed through a fiberglass bed coalescer and then to a smaller decanter tank. Fatty material concentrations of

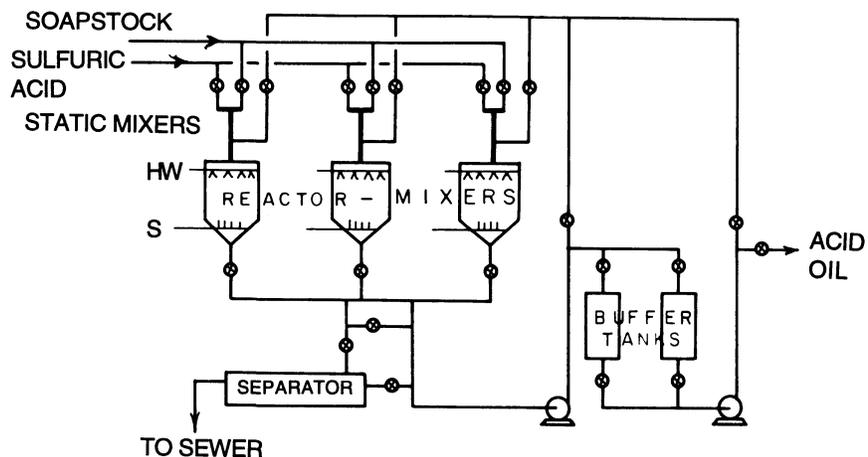


Fig. 17.3. Continuous soapstock acidulation. *Source:* DeSmet, Brussels, Belgium.

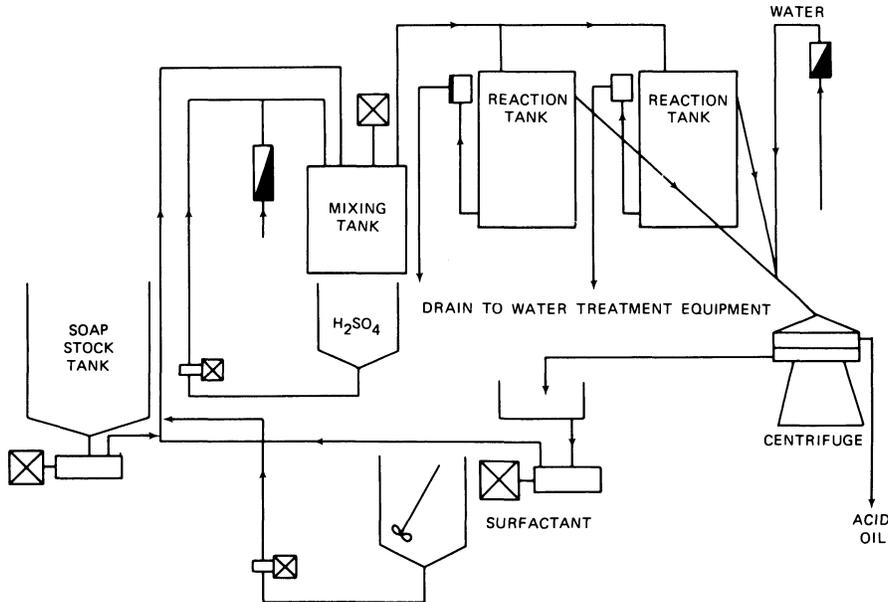


Fig. 17.4. Continuous acidulation. Source: Braae, B., *J. Amer. Oil Chem. Soc.* 53: 353 (1976).

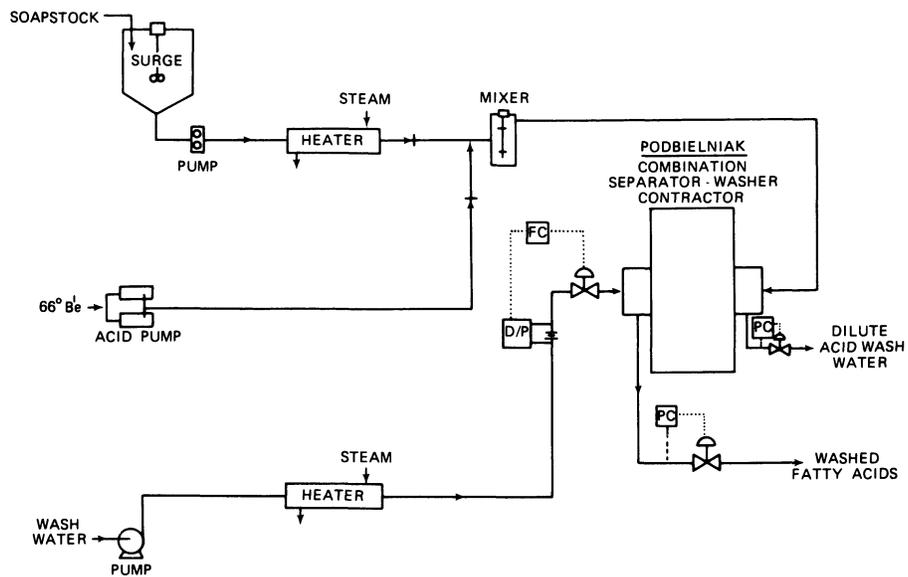


Fig. 17.5. Continuous acidulation using Podbielniak equipment. Source: Woerfel, J.B., *J. Amer. Oil Chem. Soc.* 60: 310 (1983).

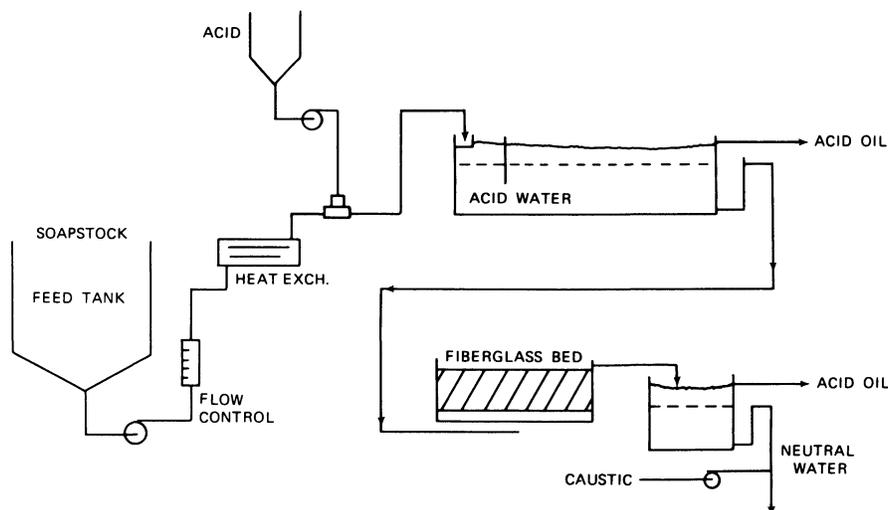


Fig. 17.6. Continuous acidulation and recovery of acid oil. Source: Mag, T.K., D.H. Green, and A.T. Kwong, *J. Amer. Oil Chem. Soc.* 60: 1008 (1983).

the acid water of less than 150 ppm can be achieved. The acid water is then neutralized for discharge to municipal sewers.

Acidulated soapstocks are largely water-free and contain approximately 20 to 30% triglyceride oil, 65 to 70% total fatty acids, and about 5% tocopherols, sterols, degraded oxidized components, pigments, salts, and color bodies (16). Some refineries preboil soapstocks with excess caustic to saponify the neutral oil components completely before acidulation. Acidulated preboiled soapstocks will have mostly free fatty acids and only small amounts of glycerides and other fatty acid compounds.

Witte (1) states that the problem of oily materials in acid water is associated with phosphatides, which are not broken down in the acidulation step and act as oil emulsifiers in the decantation step. These materials may be more effectively broken down in acidulation by the use of more severe conditions of pH and temperature. Pressure acidulation allows temperatures in excess of the boiling point of the aqueous mixture. Operation of the pressure process in one plant is said to give improved product yield and lower wastewater loads.

Acid water is high in BOD and low in pH. When properly treated to adjust pH and remove immiscible materials, it is readily biodegradable. Table 17.2 shows estimates by Boyer (17) of the wastewater loads from different operations for a plant that extracts, refines, and produces margarine, mayonnaise, and salad dressings. Acidulation is the largest source of BOD, amounting to 45% overall, or 70% if the margarine and salad oil departments are excluded.

An alternative to acidulation for processing refining lipids at the refinery location is drying the crude material. The dried material is suitable for animal feeding, and the treatment of wastewater is eliminated. If the refinery is adjacent to an extrac-

TABLE 17.2 Edible Oil Processes and Waste Loads (17)

Process	Waste load				
	Flow, gpd average	BOD, lb/d		FOG, lb/d	
		Average	Maximum	Average	Maximum
Milling and extraction	75,000	370	600	25	65
Caustic refining	11,000	220	1,000	115	400
Further processing	5,000	150	300	75	150
Deodorization	5,000	40	100	20	50
Acidulation	19,000	3,200	5,000	25	800
Tank car washing	5,000	250	1,500	125	250
Packaging	10,000	250	1,000	125	500
Subtotal	130,000	4,480	8,500	510	2,215
Margarine production	70,000	600	1,000	300	500
Salad dressing/mayonnaise	50,000	2,000	3,500	1,000	1,700
Total	750,000	7,080	13,000	1,810	4,415

FOG, fat, oil, grease; BOD, biochemical oxygen demand.

tion plant, the raw soapstock may be neutralized and added to the soybean meal in the desolventizer-toaster (DT), where it is mixed and subsequently dried with the meal. If only the output of the extraction plant is being refined, the fat content of the meal will typically be increased by about 0.4%. This approach is limited to refineries close to an extraction plant.

Another approach is to dry the soapstock, which makes it a stable product that can be stored and transported.

Patents for drum drying of soapstock were issued to workers at Central Soya (Ft. Wayne, IN) (18,19). The dried product contains 0.8% moisture, 67% fatty acid and 608 ppm (0.068%) xanthophyll and is inhibited against hygroscopicity by use of calcium phosphate. It is suited for use in poultry feed.

Beal and Sohns (20) of the U.S. Department of Agriculture (USDA) laboratory developed a process of neutralizing with sulfuric acid and drying under vacuum in either a natural-circulation evaporator or scraped-film evaporator. The product is a waxlike solid at room temperature, containing between 54 and 71% TFA. When made from nondegummed soybean oil, a high level of carotene and xanthophyll was retained. Important advantages were improved pigmentation in shanks of broilers and in egg yolks.

Although drying produces a product useful for animal feeding, the product is not suitable as a raw material for other industrial uses such as soap and oleochemicals.

Utilization of Soybean Refining Lipids

The primary use is for animal feeds, with lesser use in soap and oleochemical manufacture. Table 17.3 shows a projection of 1995 usage for several purposes (16).

For feed, the acidulated dried, or even raw, product may be shipped and used directly. For other purposes, the raw or acidulated material is a raw material for more sophisticated processing.

Individual U.S. refineries rarely process refining lipids beyond acidulation or drying. Some refineries, especially those that refine nondegummed oil, prefer to ship raw soapstock rather than to deal with the problems and costs of acidulation and treatment of acid water. The value of the soapstock represents only 1 or 2% of the total product value from a refinery, and acidulation and wastewater treatment may require an inordinate investment and commitment of management time (21).

In general, the processing to finished soaps, distilled fatty acids, and oleochemicals has been done in specialized plants that draw raw materials from a number of sources. Such plants may be part of organizations that include refineries, or they may purchase on contract from others. In regions where there is a concentration of refineries, a contract buyer can operate trucks to collect raw soapstock on a regular basis. With appropriate traffic management, rail shipments of raw soapstock are feasible.

Soybean oil soapstock-derived fatty acids have the same fatty acid composition as soybean oil-derived fatty acids and are used for similar purposes by the oleochemical and detergent industries. The value of the soapstock-derived acids is less than the crude oil value by the difference in glycerol credit and because of quality differences, such as higher color or degree of oxidation, which limit usage in some higher-grade products.

Industrial uses include ore flotation, alkyd resins, foundry products, medium-grade industrial soaps and as a fatty acid feedstock for nitrogen derivatives and other oleochemicals (see Chapter 21) (22).

Sonntag (16) reviewed a number of processes that are used or proposed for processing soapstocks. Of particular interest are processes that convert the acids to methyl esters. He points out that esters have been replacing corresponding fatty acids for a number of reasons. They are more easily produced, more economically fractionally distilled, more reactive, more thermally stable, less corrosive, and basically cheaper.

In addition to fatty acids, soapstocks contain glycerol (combined as glycerides) and unsaponifiables. Although these are recovered in some operations, it is not always economical to do so because of the small quantities.

TABLE 17.3 Future Prospects for U.S. Soybean Soapstocks (16)

Product	1987 U.S. volumes lbs	Growth potential %/yr	1995 U.S. volume lbs product
Dimer acid manufacture	3 MM	small	3.1 MM
Low-grade oleochemicals	10 MM	5	15 MM
Pet food and feed fortification	260 MM	3	329 MM
	(1.75 MMM all fats)		
Low-grade cleaning, soap, and other surfactant products	20 MM	5	31 MM

Deodorizer Distillate Recovery

Deodorizer distillate is the volatile organic material recovered as a valuable byproduct in the deodorization of fats and oils. Deodorization, a high-temperature, high-vacuum steam distillation, discussed in Chapter 14 is the last step in processing, which improves taste, odor, color, and stability by removing undesirable volatiles (such as free fatty acids, aldehydes, ketones, and other compounds formed by the decomposition of peroxides) and pigments.

Winters (4) discusses deodorization as related specifically to recovery of deodorizer distillate. In particular he presents data on relative volatility (Table 17.4) and vapor–pressure temperature (Fig. 17.7) relationship for key components.

The factors affecting volatile removal are the following:

1. High temperature increases vaporization by increasing pressure of the key components.
2. Lower absolute pressure (high vacuum) decreases the weight of steam needed by increasing its volume. At 4 mm Hg, 33% more steam is required than at 3 mm Hg.
3. Increased volume of steam increases rate of volatilization and decreases time required.
4. Different conditions will affect the composition of the distillate because of the differences in relative volatility.
5. A shortened time at higher temperature decreases hydrolysis and other undesirable reactions.

Deodorizer operating conditions are based on oil quality rather than distillate concerns. In the course of deodorization, a portion of the tocopherols and sterols are vaporized. Complete removal is not necessary, and residual tocopherols are desirable for their antioxidant effect in the finished oil.

Distillate was originally recovered from the *hotwell oil* collected from deodorizer barometric condenser systems. About 1960, wet scrubbing systems using aqueous solutions were introduced. These were soon replaced by the dry recovery systems used today, which condense by recirculated cooled distillate, thus producing a dry product.

Fig. 17.8 (22) is a schematic flow sheet for an EMI distillate recovery system. Steam and distillate vapors coming from the deodorizer at a pressure of 2 to 5 mm Hg are compressed to 50 to 60 mm Hg through one or two booster stages. The vapors pass upward through a packed tower, where they are contacted with liquid distillate cooled to approximately 60°C (140°F) by circulating through a heat exchanger. A

TABLE 17.4 Relative Volatility of Some Key Components of Vegetable Oil (4)

Component	Molecular weight	Relative volatility
Fatty acid	280	2.5
Squalene	411	5.0
Tocopherol	415	1.0
Sterol	410	0.6
Sterol ester	675	0.038
Oil	885	small

level controller in the bottom of the tower maintains a constant volume of condensed distillate in the system; the excess is continuously drawn off.

Packing in the tower is an open grid of stainless steel, to minimize the pressure drop while providing good liquid-vapor contact. Demisters are installed to minimize entrainment losses. It is very important that these be of proper design and kept in place to achieve efficient removal of droplets being carried in the high-velocity vapor stream.

Efficiency of the deodorizer distillate removal is quite high. In tests, tocopherols and sterols were recovered from the distillate and from the fatty residue in the barometric condenser water. These tests indicated more than 98% recovery of tocopherols and more than 95% recovery of sterols in the deodorizer distillate.

Fig. 17.9 (22) shows a deodorizer distillate recovery system by Elliott. This is similar in principle, but employs a scrub cooler rather than a packed tower. Also, the

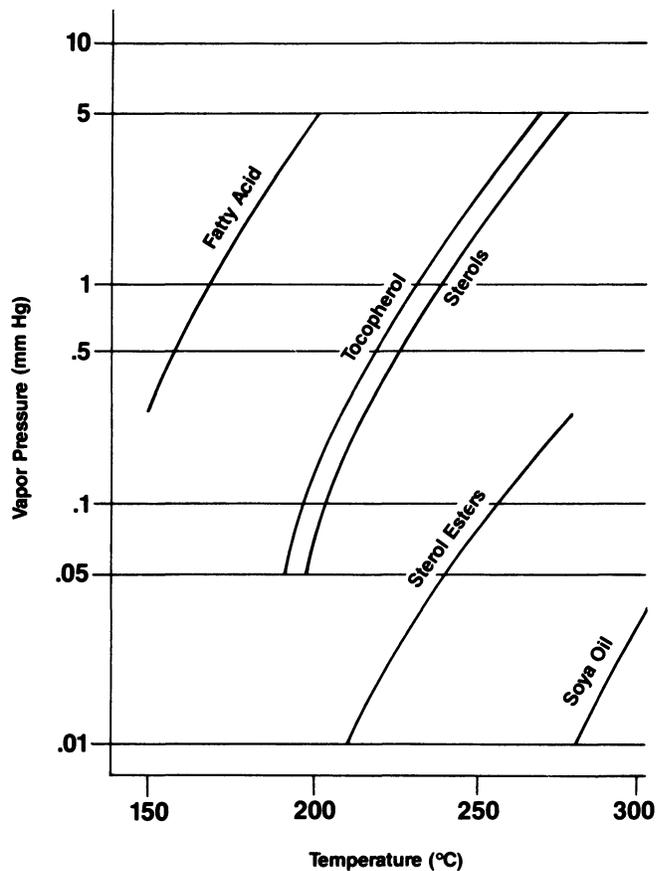


Fig. 17.7. Vapor pressure–temperature relationships for key components of vegetable oil. Source: Winters, Robert L., in *Proceedings: World Conference on Emerging Technologies in the Fats and Oils Industry*, edited by A.R. Baldwin, American Oil Chemists' Society, Champaign, IL, 1986, p. 186.

water cooler is an integral part of the scrub cooler. This sketch also shows that the scrub cooler is located immediately after the deodorizer and before the ejector boosters. This configuration is said to minimize steam consumption to the booster and conserve energy.

Where a distillate recovery system of this type is not installed, the deodorizer distillate is condensed in the barometric cooling water. This distillate may then be recovered as hotwell skimmings. Certain anionic polymers can be used to coagulate and float the greasy material to improve its separation from the water.

Recovery of the distillate as hotwell skimmings is not nearly as satisfactory as recovering it dry, because the skimmings contain a large amount of water, which must be removed. Yields of tocopherol may be reduced because of oxidation occurring in the barometric water cooling tower or during the drying.

Handling of Deodorizer Distillate

Steel tanks can be used for collection, storage, and transport of deodorizer distillates, providing that low temperatures are maintained and storage time is minimal. Distillate may be collected in unagitated tanks and allowed to cool, then heated only enough for loading. Protection from oxidation can be provided by nitrogen blanketing. Since the percentage of material is low, a period of several weeks may be required to collect a full tank car or truck load for bulk shipment.

Utilization of Deodorizer Distillate: Tocopherols

Processing of deodorizer distillate consists of highly sophisticated techniques to separate the components including molecular and fractional distillation and solvent separa-

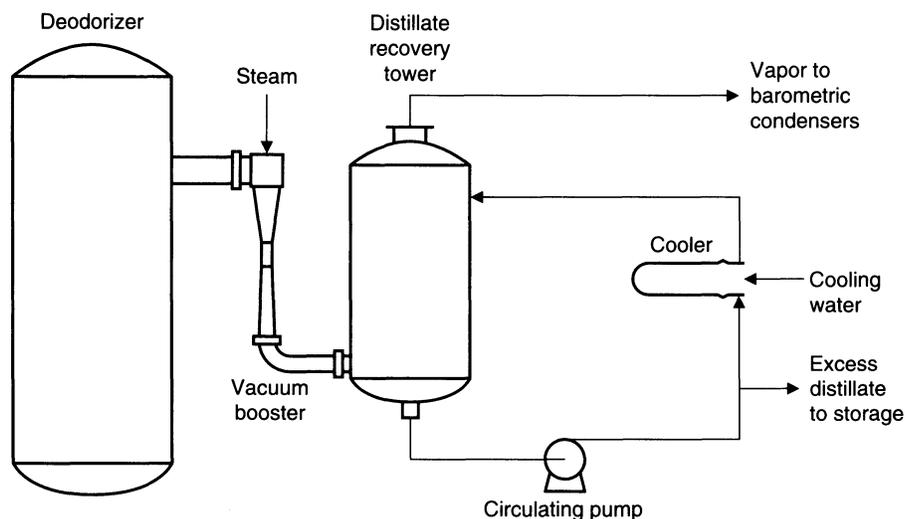


Fig. 17.8. Deodorizer distillate recovery system. *Source:* Woerfel, J.B., *J. Amer. Oil Chem. Soc.* 583: 188 (1981).

tion. In the United States there are two companies that purchase and process distillates, Henkel Corporation (LaGrange, IL) and Eastman Chemical Products (Kingsport, TN).

The primary products from distillate are vitamin E (D- α -tocopherol), mixed tocopherols used as antioxidants, and sterols used for manufacture of pharmaceuticals. A byproduct is the fatty acids remaining after removal of the sterols and tocopherols. These fatty acids are of low quality because of the extensive processing and are limited to nonfood, nonfeed, low-cost applications (3).

Table 17.5 (3) shows analysis of deodorizer distillates from several vegetable oils. Although distillate from other oils may have higher levels of α -tocopherol, the larger volume of soybean oil processed makes soybean distillate an important source of natural vitamin E.

Dougherty (23) and Buford (24) discuss the use of tocopherols as food antioxidants and comparisons with other natural and synthetic products.

The α -tocopherols have some antioxidant activity, but δ - and γ -tocopherols are more effective antioxidants and will usually constitute a minimum of 80% of the total tocopherol content of mixed tocopherols. Mixed tocopherols are used where synthetic antioxidants are not permitted or where there is a preference for a natural product.

Natural source tocopherols are widely accepted for use in foods and are regulated in the United States by the Food and Drug Administration (FDA). They are permitted by the USDA at levels of 0.03% (300 ppm) in animal fats and at 0.03% (300 ppm) or 0.02% (200 ppm) in combination with other antioxidants in poultry products. Many foreign countries permit the use of tocopherols in foods, including Canada, Japan, Korea, Australia, and all countries of the European Economic Community.

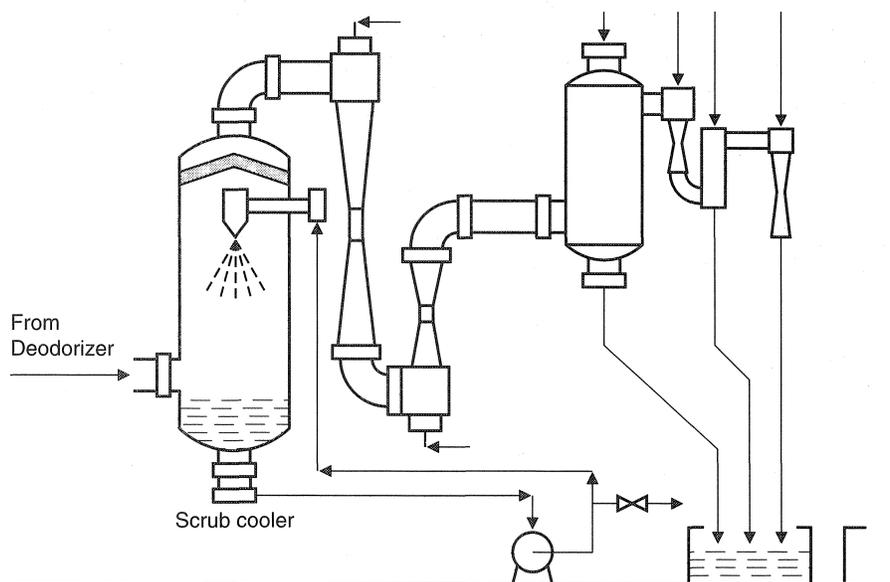


Fig. 17.9. Deodorizer distillate recovery system. Source: Woerfel, J.B., *J. Amer. Oil Chem. Soc.* 583: 188 (1981).

Antioxidant preparations containing mixed tocopherols, at various concentrations and combinations with other antioxidants, synergists, and carriers, are distributed by several U.S. companies, including Eastman Chemical Co., Kingsport, TN, (25); U.O.P. Food Products and Processing Dept., Des Plaines, IL (26); and Kalsec, Kalamazoo, MI (27).

Utilization of Deodorizer Distillate: Sterols

Table 17.5 (3) shows soybean distillate to be 18% sterols, of which 4.4% is stigmasterol. Distribution of sterol components for soybean oil is reported to approximate 20% campesterol, 20% stigmasterol, 53% β -sitosterol, 4% δ -avenasterol, and 3% δ -stigmasterol (28). This indicates soybean oil to be a good source of sterols, stigmasterol in particular.

Sterols are used in the manufacture of pharmaceuticals. Stigmasterol from soybean oil is used in the manufacture of progesterone and corticoids, whereas β -sitosterol is used to produce estrogens, contraceptives, diuretics, and male hormones (28).

Value of Deodorizer Distillate

Value of deodorizer distillate depends upon content of unsaponifiables. Table 17.6 (3) shows a typical specification. Pricing is based on tocopherol content and stigmasterol content, or both, depending on market demand for each ingredient, and is subject to wide fluctuations.

Winters (3) lists values and pricing basis over the years for a typical distillate, composed of 10% tocopherol, 14% sterol, and 2.9% stigmasterol (Table 17.7). Prices from 1961 to 1989 varied from no market in February, 1975, to \$1433 per MT in December, 1983. The tocopherol market appears to have a greater effect in determining price than the sterol market.

TABLE 17.5 Deodorizer Distillate from Different Oils (3)

Item	Sunflower	Cotton	Soybean	Rapeseed
%Unsaponifiable	39	42	33	35
%Tocopherol	9.3	11.4	11.1	8.2
% α	5.7	6.3	0.9	1.4
%Sterol	18	20	18	14.8
%Stigmasterol	2.9	0.3	4.4	1.8

TABLE 17.6 Typical Specification for Deodorizer Distillate (3)

Item	Specification
Stigmasterol	2.5% min.
Tocopherol	6.0% min.
Water	2.0% max.

TABLE 17.7. Value and Pricing Basis for Typical Distillate (3)

Typical composition: 10.0% Tocopherol 14.0% Sterol 2.9% Stigmasterol		
Date	Price basis	Value \$ (USD)/MT
06/16/61	Sterol	386
01/01/68	Toco	441
04/05/72	Mixed	649
04/08/74	Toco	897
09/03/74	Toco	1190
02/21/75	No market	N/A
04/01/75	Mixed	162
03/18/76	Mixed	311
10/27/78	Toco	661
12/31/83	Toco	1433
05/01/85	Toco	772
09/16/86	Toco	507
01/01/89	Toco	397
1989	Toco	243–397

The distillate from physical refining is lower in value than distillate from caustic-refined oil. Even though equal amounts of sterol and tocopherol are recovered, the distillate is less concentrated because of higher fatty acid content. Additionally, the oxidative quality of the physical refinery distillate is lower, as measured by carbonyl and peroxide values. Both of these factors affect the cost of handling and processing and reduce the price and total return from sale of the distillate.

Spent Bleaching Earth Utilization

Spent bleaching earth is difficult to handle, primarily because of its tendency to catch fire. This is more pronounced with highly unsaturated oils such as soybean. If spent earth is left uncovered on a warm day, ignition can occur within an hour or two. Several precautions are helpful in addressing this problem. Spraying with water and covering bins in which bleaching earth is collected and transported are simple and helpful in reducing heating. Spraying with an antioxidant has been used; while this has some effect, it does not provide complete protection and is expensive (Smith, S.J., personal communication, 1993).

It is obviously desirable to reduce the amount of oil lost in the clay. This is controlled by several factors. Well-refined oil, especially one low in soap and phosphatides, requires less clay. More efficient clay and other bleaching agents reduce the amount of clay required; even though more active clay may have higher oil retention, the smaller amount required will result in lower total amount of oil lost in the clay. The third factor is operation of the filter press. Control of pressure and flow rates and proper use of filter aid as precoat and body feed can reduce the amount of clay needed by getting maximum utilization of the clay.

Blowing the press with nitrogen results in recovery of a higher-quality oil than does the use of air or steam. Sampling each press and analyzing composite samples for oil retention is an important control practice.

A number of methods are available for treating spent clay to obtain usable oil and defatted clay which can be disposed of more easily. Klein (29) describes methods for solvent extraction with polar and nonpolar solvents, aqueous extraction, and pressure extraction. He cites the importance of processing the spent earth promptly to obtain better-quality oil and points out that distilled fatty acids from clay and from soapstocks were quite similar. Flammability tests indicated that below 5% residual fat, risk of fire is eliminated.

Economic calculations comparing solvent extraction, pressure processing, burning and returning the clay to the meal stream for a 620 MT/yr plant led to the conclusion that a refiner should either sell the spent clay or incorporate the clay into meal cake at the maximum amount allowed by law.

One plant in the United States was established to process spent clay some years ago in an area where there were several refiners to supply raw material. It closed after several years, apparently because it was not profitable (Hastert, R.J., personal communication, 1993).

A number of U.S. processors add spent clay to animal feeds, especially for cattle. This provides energy and is said to reduce caking. Burning the clay in solid fuel boilers has been practiced for more than 50 years and is still in use. Fuel content of the oil is recovered and clay is disposed of in the ash.

One interesting development is incorporating spent bleaching clay in compost consisting of wood and other waste organic materials. At least one plant is reporting using this practice (Smith, S., personal communication, 1993).

Disposal of spent clay in a landfill is not desirable if there are other materials that might be flammable. One practice being used is to spread the clay on the ground and control the heating by a water spray until it stabilizes, and then put it on a dedicated landfill.

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