# Processing Oilseeds and Oils in Germany[1]

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(EDITOR'S NOTE: *Mr. Goss conducted an investigation of the German edible oil and oilseed processing industries shortly after victory in Europe, under the sponsorship of the Subcommittee of Food and Agriculture of the Technical Industrial Intelligence Committee. The present article contains a summary of the intelligence obtained by the survey.*)

OILSEED technology in Germany differs from that in the United States in many respects, but the differences are plainly due in most cases to economic factors and dissimilarities in culinary customs. For example, the necessity for importing most of the oilseeds required by the country has fostered the development of large processing industries at ports of entry, particularly in Hamburg and Harburg, and along the navigable waterways such as the Rhine river. Most mills must therefore be prepared to handle a variety of seeds, depending upon what can be obtained by import, and consequently many types of machinery are required.

German consumers, especially those in the more populous northern areas, have adopted margarine as the chief source of fat in their diet, and its manufacture has led to the use of refining practices that in many respects are quite unlike ours.

## Oilseed Milling Practices

The Germans remove the oil from soybeans practically always by extraction with solvents and, so far as could be ascertained, seldom or never by pressing. Seeds containing higher percentages of oil than soybeans, however, are usually forepressed and then "finished" by solvent extraction. This is particularly true of peanuts, rapeseed, and castor beans. Copra and palm kernels are finished in some mills by pressing and in others by extraction. Forepressing is conducted in expellers, various kinds of hydraulic presses, or sometimes in other types of machinery, and it may be performed once, twice, or even three times. The presses used for finishing are always hydraulic. Thus, it is seen that the methods of processing in use are practically innumerable. Indeed, practically every mill is different, and most mills make frequent changes as they alter their operations to process first one kind of seed and then another.

Seeds are usually received by barge or boat, either in sacks or in bulk. Storage at the mills is limited ordinarily to the requirements for operating only a few days or, at most, a few weeks, for the raw materials are ordinarily stored in large terminal elevators at the principal seaports with delivery to the mills by barge as the seeds are needed. At some of the mills, however, one does find modern storage bins, including the auxiliary elevating and handling machinery, resembling the concrete silos and allied facilities used in the United States for storing soybeans and grain. In other plants considerable stocks of seed are stored in bags stacked in warehouses.

## Pressing Equipment

Except for soybeans, practically all seeds are forepressed, usually in expellers. All the usual types of hydraulic presses are also used, however, including both Anglo-American and cage types.

German expellers differ considerably from their American counterparts, the Anderson expeller and the French screw press, for they are primarily low-pressure, high-capacity presses designed merely for reducing the oil content of seeds prior to finishing. The most common expellers were manufactured by Krupp, and several models are in use. The older presses bear the name of "Elbex" and "Anderson," the latter being built according to the designs of the V. D. Anderson Company, Cleveland, Ohio. A newer model is designated the "Sohler Schneckenpresse" after Krupp's chief engineer and will forepress 22 to 25 metric tons of rapeseed per day. A still later model capable of similarly pressing 50 tons per day has more recently found extensive use and is known as the "VP." Another popular Krupp expeller is the Jurgens model which has a barrel whose inside diameter decreases in two or three steps from the inlet to the discharge end. The worms have much more continuous flights than do those in American presses, and the diameter of the shaft, of course, varies in steps from one end to the other to fit the cage.

Other makes of German expellers include the Müller, Miag, and Reinarz, of which the Müller is the only one used very widely. Its manufacturers have offered to build a machine capable of crushing 150 tons of seeds per day, but their plans have not advanced even to the blueprint stage.

Practices followed in the forepressing of rapeseed, peanuts, linseed, copra, palm kernels, and many other seeds are exemplified reasonably well by the methods employed to crush rapeseed, which initially contains 40 to 42% oil. The raw material is dried to a moisture content of about 5% and then flaked, usually in 5-high sets of rolls similar to those widely used in this country. The flakes are treated in stack cookers at a temperature of 160° to 200° F., being moistened to contain up to 18 to 20% moisture and subsequently dried to about 7 to 8% when discharged. The cooked seed is then pressed one to three times in expellers. If only one pressing is employed, the press cake contains approximately 24% oil, but in the case of two forepressings the respective oil contents of the cake are about 25 and 13%. Similarly, three pressings yield cakes containing 28, 20, and 13% oil. Between pressings, the cake is broken, usually in disc mills, and is again passed through stack cookers. The oils produced in all stages of the forepressing and in the finishing operation are combined prior to refining.

Finishing is customarily performed by extraction, but plate-type presses are used occasionally. In the latter cases the expeller cake is ground in disc mills

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or corrugated rolls, cooked again in stack cookers, and formed into cakes which are wrapped in press cloths and inserted into plate presses where the oil content is reduced to approximately 6%.

Copra and palm kernels are usually forepressed in about the same manner as rapeseed, but finishing, if not by solvent extraction, is accomplished in cage presses. In some mills copra and palm kernels are forepressed in the Meinberg continuous press, which is a modification of the cage press installed horizontally instead of vertically. Its operation is entirely automatic, the press being filled, closed, opened, and its contents discharged by hydraulically operated mechanisms controlled by a timer.

### Solvent Extraction

In most cases solvent extraction is employed for finishing, particularly in the production of the so-called "soft" oils such as those obtained from rapeseed, peanuts, sunflower seeds, and soybeans. The apparatus used most commonly is a multiple-contact, countercurrent, batch type, consisting of a battery of about 10 extraction kettles, but several kinds of continuous equipment are also operated. The forepressed cakes, or whole seeds in the case of soybeans, are broken by means of disc mills or corrugated rolls and are then flaked by a single passage between a pair of smooth rolls. The flakes are charged into extraction kettles, each of which holds to 2 to 3 tons of meal. Filling is accomplished through manholes in the top, and each kettle has a discharging door in the side near the bottom. There is a wedge-wire or equivalent screen to provide a false bottom on which the contained seeds rest, and a vertical shaft carries a horizontal arm which sweeps the surface of the screen. This is used, however, only while evaporating solvent from the marc.

When the extractors are filled, solvent is pumped through about five of them in series, using a sequence of operations that provides countercurrent multiple contact. Every few minutes a freshly filled kettle is added to the line, and a spent one is simultaneously disconnected for subsequent removal of the solvent. This is accomplished, after draining, by blowing live steam through the mass while the stirrer is operating.

The loss of solvent, concentration of oil in the miscella, and oil content of the meal are about the same in the operation of German extraction batteries as in American extraction plants which process soybeans. After filtration of the miscella, the solvent is removed from the oil in two stages, the first of which is accomplished in any of several types of evaporators. Some of these employ horizontal steam tubes or coils; others, vertical or inclined steam tubes; and some, vertical tubes in a steam shell arranged for evaporation from falling films inside the tubes. In practically all cases, 90 to 95% of the solvent is distilled in this apparatus, and the remainder is removed by countercurrently scrubbing the oil with superheated steam in a vertical column. This vertical column may contain packing, bubble caps, tubes arranged for falling-film evaporation, or various types of baffles over which the oil flows downward in thin films. The superheat is so controlled as to yield a crude oil which is substantially dry.

The two most widely used continuous extraction systems in Germany are the Bollman, or Hansa-Muhle, and the Hildebrandt. Both are employed in this country, too, and the German plants are practically identical with the American installations. The former system consists of a paternoster, or chain of baskets which have perforated bottoms. It roughly resembles a bucket elevator. Solvent is sprayed upon the flakes and percolates through them as it runs downward from basket to basket. This system was developed at the Hansa-Muhle A.-G. in Hamburg, where four extractors, having a combined capacity of 1,000 metric tons of soybeans per day were operated. The Hildebrandt system was pioneered by the Harburger Oelwerke Brinckmann und Mergell at Harburg, and this company operated 9 extractors which also processed a total of 1,000 metric tons of soybeans per day. This extractor is a vertical U-tube through which flaked soybeans or residues from expeller pressing are propelled slowly by internal screw conveyors countercurrently to a solvent for the oil.

The equipment for treating miscella in the continuous extraction plants is of the same general type as that employed in batch extraction. The recovery of solvent from the meal, however, is accomplished in a series of steam-jacketed screw conveyors like those used in American soybean mills. Toasting soybean flakes after removal of the solvent is not practiced in Germany, as it is in the United States.

The Miag extractor, which is essentially a paddle wheel standing on edge and revolving inside a closely fitting race, is used to a limited extent in Germany. Another type is the Fauth extractor, composed of a series of horizontal screw conveyors and specially built expellers. Extraction takes place countercurrently in the screw conveyors, and the flakes are pressed in the expellers while passing from each section to the next, to remove entrained solvent. The Tyca extractor is also used in one German mill but is practically unknown in this country. It is a vertical column containing a series of trays, one below the other, each of which has a perforated false bottom. The flakes pass downward, being moved over each tray by a scraper before falling to the next lower one, while solvent or partial miscella is sprayed on the contents of each tray. The miscella collected on approximately each third shelf is pumped to the next higher series of two or three shelves. Another extractor, the Bohm, is of German origin and has been widely advertised, but it does not appear to have been in commercial use in Germany.

In normal times these German extraction plants utilized a paraffinic naphtha which boiled between approximately 145° and 180° F., but during the war they resorted to a synthetic benzine having a variable boiling range, usually about 125° to 200° F. This proved extremely unsatisfactory both because the heavy and light fractions were lost rapidly and because the synthetic hydrocarbons tended to dissolve in and to emulsify with water rather readily. Benzol was also used as a solvent on a limited scale during the war, and trichloroethylene was employed by the one mill which recovered fat from cocoa residues.

### Phosphatides

The separation and refining of phosphatides from crude soybean oil is an essential part of the oilseed processing industry, and these materials are also recovered from other oils to some extent. The practice was originated to prevent the formation of sludge during the storage and shipment of crude oil, but the primary purposes of the operation now are to produce lecithin to be used as an anti-spattering ingredient for margarine and, in conjunction with other treatments, to impart to soybean oil a certain amount of resistance to reversion. The freshly extracted crude oil is violently churned with about 5% of water at 140° to 195° F. in a continuous mixer, and the resulting sludge of hydrated phosphatides and occluded materials is removed in a centrifuge, in much the same manner as is practiced in this country. In Germany, however, the once-clarified oil is again washed and again centrifuged, not for the purpose of enhancing the lecithin yield but to eliminate the lecithin and similar constituents as completely as possible. Indeed, the second washing with water is sometimes followed by a third with a solution of aluminum sulfate, sodium sulfate, and sulfuric acid.

For use in margarine, the phosphatides are dried at moderate temperatures and bleached with hydrogen peroxide. Other uses require the removal of the 30 to 40% of crude oil which the product contains. In these cases, the oil is extracted by means of acetone and replaced with cocoa butter or a refined oil of some type.

## Refining Practices

Refining practices in Germany are radically different from those observed in the United States. Neutralization is always conducted batchwise, in kettles, and German technologists feel that continuous processes for neutralizing, deodorizing, or any other steps in refining, yield results inferior to those achieved by batch operation. Nearly all German refining consists in the preparation of "hard" and "soft" oils which are subsequently blended for use in the manufacture of margarine. The hard oils are frequently designated as "Crisco" and may be hydrogenated peanut or whale oils, palm kernel or coconut oils, hardened rapeseed oil, or practically any other fat which melts at the proper temperature. The melting point is adjusted to 40°-42° C. in the summer and 30°-32° C. in the winter. A so-called half-hardened product melting at 34°-36° C. is produced in some cases. In the manufacture of margarine, the hard and soft oils are mixed in the ratio of 60:40 or 65:35.

In Germany's more modern refineries, neutralization, washing, drying, and bleaching are all conducted in the same kettle, which is completely closed so that vacuum can be employed for drying and treatment with the bleaching agent. In nearly all plants, however, there will be found one or more of these closed kettles and several older ones which are open at the top and suitable only for neutralization and washing. Separate tanks are used for drying and bleaching the oils processed in these.

The neutralizing kettles have heating coils or steam jackets in the lower half, and spray heads for lye and water are mounted in the top above the surface of the oil. Most of these tanks contain mechanical stirrers, but agitation in some is obtained by blowing live steam or even air through the oil. Soft oils are neutralized to a content of 0.04 to 0.10 percent FFA and are then washed three or even four times with hot water. The exact procedures vary greatly from mill to mill, and when processing soybean oil almost all refiners employ a large number of washings with a variety of reagents to reduce the content of lecithin and other minor constituents as much as possible. A typical sequence of operations employed on soybean oil at one of the leading refineries is as follows:

1. Wash 65 metric tons of degummed soybean oil with 5° to 6° Bé. lye, 100% of theory, at 100° C., without stirring.
2. Wash with 2,000 liters of aqueous solution containing 180 kg. of soda ash at 100° C. with agitation by means of a turbine-type stirrer.
3. Wash with 2,000 liters of aqueous solution containing 150 kg. of soda ash at 100° C., with stirring.
4. Wash with a slurry made by mixing 300 kg. of soda ash with 150 liters of a 50% solution of water glass, cold, with stirring.
5. Wash four times with 4,000 liters of water each time, at 100° C., with stirring.
6. Dry the oil by evacuating the kettle.
7. Treat with 1% of acid-activated earth under vacuum for 30 minutes at 100° C., with stirring.
8. Cool to 70° to 80° C. and filter.

Oils are hydrogenated in Germany chiefly to produce blending stock for margarine, and for this use a high concentration of iso-oleic acid is desired. The majority of refiners, therefore, use a non-selective catalyst, such as reduced nickel formate, in contrast to the highly selective forms of nickel that have been developed in the United States for minimizing the formation of iso-oleic acid in shortenings. A few German hardening plants use a catalyst of dry-reduced nickel on kieselguhr, but most of them employ nickel formate which is reduced in some of the oil at 240° to 260° C. and then added to the bulk of the raw material to produce a concentration of about 0.1% nickel. The catalyst is reused many times, sometimes as many as 50, but it is more usual to withdraw about 5% of that filtered out of each batch of hardened oil and to replace it with fresh nickel before recycling the catalyst. Hydrogen is manufactured in all but two hardening plants by the electrolysis of potassium hydroxide; in the other cases a steam-iron process is employed.

The converters for hardening oils vary greatly in design and the manner of use, but they are generally similar to those used in this country. After purification, the gas is blown through the oil at a temperature of about 180° C. and a pressure which ranges, according to the practices of individual mills, from 3 to 30 atmospheres. In some equipment, agitation of the oil is obtained by circulation of the hydrogen, and in others there are stirrers which provide intimate contact between the phases. In some plants the hydrogen passes through several converters in series, contacting nearly completed oil first and a fresh charge last, while other refiners prefer to use parallel flow of hydrogen through all their converters.

Occasionally, particularly in the case of soybean oil having a low content of free acids, hydrogenation is performed before neutralization. It is necessary first, however, to remove mucilaginous materials by washing and treatment with activated earth.

Deodorizers are similar to those used in typical American refineries which employ batch equipment, except that they are often installed in tandem and used for processing oil in two stages. Preliminary deodorization in these installations is conducted in the primary still under an absolute pressure of 20 or 30 millimeters, and the oil is then transferred to the secondary still where the pressure is about 10 millimeters. Steam flows through two kettles in series, countercurrently to the oil, and it is therefore necessary to provide a steam jet to pump the vapor from the secondary to the primary still. The temperatures of deodorization are usually somewhat lower than represented by American practices. For most oils a treatment for 6 to 8 hours at 300° to 320° F. is considered adequate, but for soybean oil the temperature is 25° to 40° higher and the time 2 to 3 hours longer. The consumption of direct steam is about the same as in American refineries.

### Margarine

Prewar German margarine was made by blending 18% of ripened skim milk with hard and soft oils and a number of minor constituents. Those margarines of high quality contained chiefly peanut, coconut, and palm kernel oils while the grades of lower quality were made principally of soft soybean oil and hydrogenated whale oil. During the war the skim milk was replaced by water, and practically the only fats available in recent years have been hardened and unhardened rapeseed oil. At present a typical margarine contains approximately 48% hardened rapeseed oil, 32% soft rapeseed oil, 1.5% salt (often omitted), 2.5% glucose, 0.2% potato starch, 0.5% lecithin, 0.005% carotene, and enough fish liver oil to elevate the vitamin A potency to 20 international units per gram of margarine, with water completing the percentage. Some of the minor ingredients are omitted when not available.

The methods and equipment used for the production of margarine vary with the vintage of the plant, but they are reasonably uniform in the more modern establishments. Specially designed churns mix the water or ripened milk with the fat, and the emulsion then passes over a chill roll. It is next subjected to a vigorous shearing action by passage between polished granite rolls, after which it is aged for several hours. Finally, before packaging, the semi-solid emulsion is blended with the water-soluble minor constituents in a mixer which operates under vacuum and produces a suitable texture in the product. The oil-soluble ingredients are added in the churns.

A product known as "Kunstspeisefette," remotely similar to American shortening, was made in several German mills before the war. Margarine churns or similar apparatus whipped air into coconut or palm kernel oil while the fat was held at a temperature barely above the solidification point. The emulsion then flowed into pans or molds which passed through a tunnel cooler where solidification occurred.

### Reversion of Soybean Oil

The reversion of soybean oil is widely recognized phenomenon in Germany where it is known as "Umschlag." Nearly all the German technologists attribute it to lecithin, and the methods for minimizing its occurrence are based upon removal or inactivation of this constituent. Other factors are considered to contribute to the deterioration of organoleptic quality, such as linolenic acid, methyl-n-nonyl ketone, and traces of soap, but they are generally considered to be either of minor importance or impractical to eliminate.

The most common recipe used to combat reversion, one highly recommended by many Germans, consists in initially removing lecithin from the oil with extreme thoroughness. In order for the treatment to be effective it is claimed that the oil must be produced by solvent extraction, from sound beans, without heating the oil excessively or otherwise damaging it until after the lecithin is separated. Expellers, according to one proponent of the remedy, will cause burning of the oil and consequent "setting" of the lecithin. It is important, too, that evaporation of solvent from the miscella be conducted without allowing oil to contact steam-heated surfaces that are not continuously bathed with miscella, for deleterious "burning" is claimed to occur at such places.

Removal of lecithin is accomplished, as previously described, by at least two washings with hot water, each being followed by centrifugal separation of the sludge. At some mills, even more drastic washing is administered with such solutions as a mixture of aluminum sulfate, sodium sulfate, and sulfuric acid. American practice is to wash with water but once, if at all; and, moreover, most American soybean oil is produced in expellers. That part of the lecithin which cannot be removed by washing prior to neutralization is subsequently inactivated by the use of 0.01% of citric acid in the deodorizer.

Another measure for combatting reversion, for which one German operator claimed outstanding virtue, consists in first inactivating the lecithin in the whole beans by a most violent exposure to live steam. So intense is this treatment that the moisture content is raised by 4% and the temperature to 212° F. in 90 seconds. If these changes require a longer time, i.e., as much as 120 seconds, later steps in the process are said to be ineffective. After the steaming, oil is extracted from the beans in the usual manner and washed to be freed of lecithin. The crude oil is next heated to 465° F. in a tube furnace, 90 minutes being allowed for it to reach this temperature, and is then cooled and further processed in the usual manner. The oil loses considerable color during the treatment at this high temperature, so that less earth is required during bleaching. The use of citric acid when deodorizing this oil is said to be unnecessary, and the product is claimed to keep for a year or more under ordinary conditions of storage without reverting.

Whether the preceding alleged remedies for reversion are effective can be ascertained only by trying them experimentally, for the complete absence of soybean oil in Germany during the past several years makes it impossible to obtain commercial samples of finished oils for evaluation. The results of tests conducted at the Northern Regional Research Laboratory on prevention of reversion will be presented later.

### Effects of World War II

Damage to Germany's oilseed mills and refineries due to military action varies greatly. Some mills were practically demolished, while others were left nearly intact. In general, the German technology appears to have lagged behind ours in the past decade, and bombings have so decimated the industry that many years will be required to rebuild it sufficiently to assume a position in world trade approaching that which it held in the decade preceding World War II.