

Vegetable Oils and Fats for Edible Use

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Crude edible vegetable oils are subjected to various types of processing for several reasons. One is consumer preference. Most people prefer to eat light-colored and bland oils. The preference stems partly from the apparently reasonable but incorrect assumption that only colorless, odorless, and tasteless oils and fats are pure. It is true that such products can be used without masking or detracting from the characteristic flavor and palatability of the foods to which they have been added. In the United States the only notable exception is olive oil, which is prized primarily because of its own odor, flavor, and color.

From the oil processor's standpoint, purification of crude oils is advantageous. Some consumers could be persuaded to accept a few oils having characteristic flavors and odors, but marketing a wide variety of oils of different origins is greatly facilitated by purifying practically all of them to the point where their origin is not evident to the senses.

Two factors besides preference and convenience are responsible for the existence of vegetable-oil refineries. A number of oils, including some of our most common and plentiful oils, are practically inedible in the crude state and must be processed to become edible. The supply of naturally liquid oils is greater than the supply of naturally semisolid, or plastic, fats, but the

demand is just the reverse. Therefore, in order to supply the big demand for the scarce plastic fats, the abundant liquid oils have to be converted to semisolid fats of good quality.

Because of those requirements, a large and widely dispersed industry now converts crude oils from many sources into a variety of refined edible products. The industry may appear complex, but actually it consists of a number of more or less standardized operations, or unit processes—refining, bleaching, hydrogenating, winterizing, and deodorizing, which are combined and modified to meet special conditions. Nearly all edible vegetable oils are first subjected to refining and bleaching. Then they may be deodorized and go directly to consumers, or they may be processed further to yield either winterized oils or so-called hardened fats. Regardless of the kind and number of intermediate steps, deodorization is nearly always the final step in processing any edible fat of vegetable origin.

PURE FATS OR OILS comprise a mixture of fatty acids chemically combined to form what the chemist calls triglycerides. Refining is therefore concerned with the removal of undesirable nonglyceride components. In vegetable oils, the impurities normally consist of oil-soluble substances, which are extracted from the seed along with the oil, particles of meal, gummy substances, and degradation products of the oil itself. The amounts and kinds of the impurities depend mainly on the type and origin of the seed processed and the method of extraction. The undesirable constituents generally amount to less than 10 percent by weight of the crude oil—more often to only 3 to 5 percent.

The oldest and most important

method of refining vegetable oils for edible use consists in treating the crude oil with a solution of caustic soda. It looks like a simple process, but it involves complicated chemical and physical phenomena. The caustic soda reacts with the free fatty acids that are present in the crude oil to form soaps, which are insoluble in the oil and therefore tend to pass into the water phase where hydration (absorption of water) begins. However, the concentration of the remaining caustic soda in the water is so high that the soap is kept out or is thrown out of the water solution by a phenomenon called salting out.

THE RESULT of the different reactions is the transformation of the water, the caustic soda, and the soap into numerous minute, soft, gelatinous particles. Simultaneously the other nonfat substances—phosphatides, protein, protein-degradation products, and other gummy substances—are forced out of solution in the form of coarse particles suspended in the oil. Some of the caustic soda reacts with a portion of the fat or oil to form more soap and free glycerin. Almost as soon as the various types of particles are formed they begin to clump together, or coalesce. As the particles grow in size and gather in the color bodies and other colloidal impurities, they also adsorb (occlude) some of the refined oil. The oil remaining after completion of the operation is much lighter in color and retains only traces of nonfat compounds.

In some of the older and smaller refineries, this treatment of crude oil with caustic soda is carried out in large open kettles. Generally, the kettles are cylindrical, have cone-shaped bottoms, and hold 60,000 pounds of oil apiece. Each kettle has a steam coil for heating the charge and a stirrer for mixing. Oils like cottonseed, soybean, and peanut are charged into the kettle at a temperature of about 70° F. After the bubbles of air have escaped from the oil, the stirrer is set for rapid mixing, and the

caustic soda is added. A milklike emulsion forms immediately; as the mixing continues small particles of soap appear and start to grow. After a mixing period of 10 to 45 minutes, the surface of the mixture of oil and caustic solution gradually assumes a slightly granular texture because of the clumping together of soap particles. This is known as the pin break. Stirring is slowed down, and steam is turned into the heating coils to raise the temperature of the oil to about 140° F., at which point relatively large flakes of soft soap form. Heating and agitation are discontinued, and the mixture is allowed to separate into an upper layer of clear, refined oil and a lower layer of semisolid soap stock, called foots. The two layers are separated after cooling and hardening of the soap stock.

The refiner who employs the batch method generally uses enough caustic soda to neutralize the free fatty acids in the oil and provide an excess of 0.2 to 0.6 percent, based on the weight of the crude oil. The exact excess of caustic needed is the amount that will produce the desired color in the oil with the lowest refining loss. An excess of 0.2 percent is often sufficient for peanut oil, but cottonseed oil often requires 0.5 percent or more. The concentration of caustic soda ordinarily used for refining is 8.0 to 16.4 percent, which is determined and expressed on an arbitrary specific-gravity scale as degrees Baurmé—in this case, 12° to 20° Baumé. The lower concentrations are used for the purer and more easily refined oils.

CONTINUOUS methods of refining vegetable oils with caustic soda have largely replaced the batch method in the United States. Continuous refining was first advocated in Europe in the 1890's. Only in the early 1930's, however, did the development in continuous centrifuges, proportioning pumps, and general mechanical equipment reach a point where the process became practical and economically feasible.

Continuous operation has the advantage of eliminating large and intermittently unused equipment in favor of smaller and continuously working apparatus. Also the amount of material actually being processed at any moment is relatively small, so that the process is flexible and responsive to the will of the operator. In the batch method, an error in judgment might necessitate re-refining a batch of 60,000 pounds of oil, but in the continuous method a similar error can be detected and corrected before an appreciable amount of oil is damaged. Another important advantage of continuous operation is that the over-all time of contact between oil and caustic soda is only 2 or 3 minutes, and the attack on the oil itself by the caustic soda consequently is kept to a minimum. The centrifugal force employed in separating the soap stock and oil is tremendously greater than the force of gravity, which acts during settling in the kettle process. Because the rate of separating the refined oil and soap stock is higher in centrifuging than in settling by gravity, the excess caustic soda has less time in which to attack the refined oil and thereby increase the refining loss.

In the continuous process, the oil and caustic soda solution (both at 75° to 85° F.) are delivered to separate measuring devices, which usually consist of a positive displacement-type pump for the oil and a synchronized adjustable metering pump for the caustic soda solution. After the proper proportions of the oil and caustic soda are measured by the respective pumps, the two streams are combined and discharged into a mixing chamber, where an emulsion is formed. After about a minute in the mixing chamber, the water-oil emulsion is forced into a tube-type heat exchanger, where hot water, or low-pressure steam, quickly heats the emulsion to 140° F. and causes it to break, or separate, into soap stock suspended in the oil. The oil and soap-stock mixture is now conveyed to a special, high-speed centrifuge, which

separates the mixture and discharges two continuous streams, one consisting of refined oil that contains a small amount of soap stock and water, and the other consisting of a small amount of the semisolid soap stock. Normally, less than 3 minutes elapse from the time the crude oil enters the proportioning device until it emerges as refined oil.

The oil from the refining centrifuge can be settled, filtered, and stored. It is customary, however, to wash it almost immediately once or twice with 5 to 10 percent of hot water (180° F.). Washing is also carried out continuously by mixing the refined oil with hot water and centrifuging again to separate the soapy wash water and oil. The washed oil, containing about 0.5 percent of moisture, flows to an automatic vacuum-drier system, which is a vertical cylindrical tank in which a low pressure (1 to 2 inches of mercury) is maintained by steam-ejector pumps. The heated, wet oil is sprayed into this tank, where the water is evaporated, and the oil, which contains less than 0.1 percent of moisture, is removed at the bottom.

A modification of the continuous refining process was introduced about 1942. It is said to reduce the refining loss of an oil to nearly the theoretical minimum. The new process, known as the continuous soda ash process, subjects an oil to two separate refinings. In the first, a solution of soda ash (which is a much weaker alkali than caustic soda and, therefore, cannot attack the oil) removes most of the free fatty acids with which it can combine to form soaps. The second refining, which is carried out with caustic soda solution, removes the pigments and the remainder (about 0.1 percent) of the free fatty acids.

While most vegetable oils processed in the United States for edible use are refined by one of these three processes, or modifications of them, several other processes are used, too. The simplest of these is a water washing or degumming, which is referred to as refining by hydration. Warm, dilute solutions of

weak alkalis or salts may be used, but as a rule only warm water is employed. Warm water reacts with some oil-soluble substances, such as phosphatides, proteins, and other gummy materials, to form relatively insoluble products, which can be separated from the oil by continuous centrifuging.

Water washing before alkali refining reduces the total refining loss of an oil, but that advantage probably is appreciable in only a few instances. Some oil is always lost during washing, and the washed oil may be more difficult to refine because of a greater tendency to form stable emulsions or emulsions that are hard to break. Crude soybean and corn oils are washed primarily to separate and recover the phosphatides. About 8 million pounds of soybean phosphatides, called lecithin in the trade, and a half million pounds of corn phosphatides are produced annually in the United States by this process.

Certain crude oils that contain minor amounts of impurities other than free fatty acids can be refined by a process known as steam refining. It is merely a high-temperature steam distillation under reduced pressure. The crude vegetable oil is heated to about 450° F. and maintained under a pressure of 0.25 inch of mercury or less while steam is passed through it. The steam strips the free fatty acids out of the oil. The process is used somewhat in Europe but not often in the United States.

Solvent refining has been developed so recently that only a few plants have been built to use it. By such a method, crude oils are treated with solvents that have the property of preferentially dissolving either the oil itself or the impurities in the oil. Each type of solvent finds use in one or another process based on the property of the solvent. For example, free fatty acids may be separated from crude oils by a mixture of water and isopropanol, an alcohol. In this mixture the fatty acids are relatively soluble and the oil relatively insoluble.

Another process of this type employs propane, a simple petroleum hydro-

carbon. As propane is a gas at ordinary temperatures and atmospheric pressure, the process must be operated at a high pressure, at which the propane is liquid. Still another process, which involves both refining and fractionation of the oil, employs furfural.

BLEACHING is necessary to remove the color bodies, or pigments, not removed from crude oils during alkali refining. Pigments common to many vegetable oils include the carotenoids, which are red and yellow, and the chlorophyllides and pheophytin, which are green. In addition, refined oils contain degradation products of various colors and unknown character. Some oils may contain uncommon pigments; for example, gossypol, a yellow pigment, is found only in cottonseed oil.

The amount of any one pigment to be removed by bleaching is always small. For example, objectionably green oils may contain only 0.0002 percent of a chlorophyllide. Refined cottonseed oil usually contains only about 0.0003 percent of carotenoid. Crude palm oil has a relatively high content of those pigments, to which it owes its deep, orange-red color, but even its content of β -carotene is only 0.005 to 0.20 percent.

Bleaching is generally accomplished by the action of bleaching earths, or clays, or various forms of carbon. Those substances can adsorb on their surfaces the pigments that are dissolved in the oil. The exact manner by which this adsorption is brought about is not fully understood. However, it is known that in the bleaching process the amount of color bodies which are removed from the oil depends on the nature of the adsorbent used, its surface area, the concentration of the color bodies in the oil, and the temperature.

Almost any solid material that is chemically inert toward the oil can be used to adsorb the color bodies, provided that the solid material is in a state of subdivision fine enough to provide the necessary surface area. How-

ever, various economic factors limit the selection of adsorbents for bleaching oils to several types of clays and to activated carbon.

The earliest clay used in the bleaching of vegetable oils was fuller's earth, which occurs naturally in extensive deposits. The mineral is semiplastic when wet and rocklike when dry. The active adsorbing ingredient is a complex form of hydrous aluminum silicate. As mined, the mineral usually contains 40 to 60 percent of free moisture, and its preparation as an adsorbent consists in heating it to remove moisture and grinding it to a fine powder. Grinding does not produce the surface area required for adsorption, but merely makes it more accessible.

In recent years, fuller's earth largely has been supplanted by activated clays, which are more effective adsorbents. The clays are inactive as mined. High adsorbing power is imparted to them by treatment with strong mineral acids, after which they are rinsed with water and ground. Activated clays intended for removing the green pigments from vegetable oils are left slightly acidic after washing with water to remove most of the strong mineral acid.

Activated carbon, or charcoal, is the third type of adsorbent commonly used. It is effective in removing certain types of compounds, but it is expensive and it adsorbs large amounts of oil that are not removed from the spent carbon.

Oils are almost always bleached by batch methods in kettles with capacities of 15,000 to 35,000 pounds of oil. The kettles may be open, or they may be constructed so that the bleaching can be performed under a vacuum. In either case, they are equipped with steam coils for heating the charge and with agitators for intimately mixing the adsorbent and oil.

The oil to be bleached is pumped into the kettle and heated to slightly above 212° F. before the clay is added, usually in amounts ranging from 0.5 to 4.0 percent. Just enough clay is used to produce the desired degree of bleaching. If activated carbon is used,

it is used in conjunction with the clay and in amounts of 5 to 10 percent of the amount of clay used. After addition of the adsorbent, the oil-solid mixture is agitated for 15 to 20 minutes. A longer contact period tends to darken the oil and partly defeat the purpose of the operation. At the end of the mixing period, the bleached oil and adsorbent are separated by filtration. If the bleaching was conducted under vacuum, the oil is cooled before filtering.

The plant process is controlled by laboratory refining and bleaching tests, designed to determine how much and what types of adsorbents are necessary to produce the desired color in the bleached oil. The amount of permissible color depends on the type and quality of the end product. For instance, oils to be made into high-grade creamy shortenings must be bleached to a very light color; oils intended for cooking purposes can be darker; and oils intended for use in mayonnaise and other salad dressings can be bright yellow. Whenever possible, oils having a minimum color before bleaching are selected for processing into light-colored products.

Determination of the color of vegetable oils is made by matching the color of the oil against a combination of standardized red and yellow glasses. The red glasses form a series of small increments of color increasing in intensity in accordance with a standard color scale. The yellow glasses form another series, but, because the eye is less sensitive to variations in yellow, the differences in the yellow glasses are many times greater than in the red glasses, and the oils need only fall within relatively wide limits.

AFTER REFINING AND BLEACHING, an oil may be further processed by any one of several procedures, depending on its final use. One is its separation into the higher (semisolid) and lower (liquid) melting fractions by crystallization. The object of such a process, called winterization or desteariniza-

tion, is to produce salad oils that will remain liquid or "bright" in household refrigerators at 40° to 50° F. Oils that remain liquid at refrigerator temperatures are preferred by housewives for storage in the refrigerator. Manufacturers of mayonnaise and other salad dressings use these oils to prevent the emulsion from breaking and the separation of the oil and water ingredients on cooling.

An oil is considered to be adequately winterized if it will remain perfectly clear when kept at 32° F. for 5½ hours. Usually a commercially winterized oil will remain clear for 12 hours or longer. Both time and temperature must be specified, because crystals of fats grow very slowly in cold oils. It is possible for an oil stored at a low temperature to remain perfectly clear for several weeks but to solidify partially after storage for several months.

Cottonseed oil is practically the only vegetable oil now winterized on a large scale. Soybean and corn oils intended for use as salad oils are chilled and filtered to remove traces of wax, but that is not true winterization. Soybean, corn, sesame, and sunflower oils are natural salad oils and do not require winterization. Rice-bran oil is relatively easily winterized, but it is of minor importance because of its limited production. Peanut oil cannot be winterized by the ordinary method used for cottonseed oil because gelatinous and nonfilterable crystals are formed when it is chilled.

Winterization is a batch process, in which 40,000 pounds of oil may be treated at one time. The oil is pumped into long, narrow tanks in a refrigerated room, or into large, well-insulated metal tanks that contain cooling coils. In either case, the tanks are constructed so that no part of the oil is more than a few feet from a cooling surface. The cooling system is arranged so that a small temperature differential (usually 10° to 25° F.) can be maintained constantly between the cooling surface and the oil.

The temperature of the oil is re-

duced to approximately 40° F. at a rate of about 0.5° F. an hour, which requires 2 or 3 days. At about 40° F., crystallization commences and releases heat, so that the temperature of the mass of oil rises 2° or 3° F., even though the rate of heat removal is kept constant. After a short time, the temperature of the oil starts to go down again; when it reaches a point slightly below that at which crystallization began, the oil is filtered in filter presses precooled to a temperature slightly below that of the oil. The yield of winterized cottonseed oil usually ranges between 65 and 75 percent.

The present winterization process is the least satisfactory of the processing operations. It is slow. Care must be taken during the chilling to produce the right type and quantity of crystals. Filtration is difficult. Improper handling of the chilled oil causes the soft crystals to break and makes the separation of the oil and crystalline material almost impossible.

Hardening, or hydrogenation, the process which converts naturally liquid oils into more valuable plastic fats, is widely employed. The techniques have advanced to the point where hydrogenated vegetable oils have characteristics superior to those of hog and beef fats, which they originally were meant to imitate. In fact, hydrogenation now permits processors to turn out a variety of plastic fats with desirable physical characteristics that are specified before the operation starts—tailor-made, so to speak. The characteristics might be controlled plasticity over definite temperature ranges, or complete and rapid melting at a specified temperature, or superior emulsifying properties.

Besides hardening, two incidental benefits are obtained: The color of the final product is lightened, and greater resistance to rancidification and other deteriorative processes during storage and use is imparted.

Chemically, hydrogenation is the addition of gaseous hydrogen to part of the carbon-to-carbon double bonds which form part of the molecule of

liquid fats. The addition of hydrogen at the double bonds occurs rapidly only in the presence of a catalyst, a foreign substance which itself remains unchanged during the reaction and is removed from the fat after the hardening has been completed. Nickel and several other metals, with specially prepared surfaces, are effective catalysts. Generally, hydrogenation is accomplished by intimately mixing the finely divided metallic catalyst, hydrogen, and oil and heating the mixture at atmospheric or higher pressure.

The catalyst used in commercial hydrogenation to form plastic fats consists of finely divided nickel. The preparation of the nickel varies somewhat, and special substances may be added to increase its catalytic activity. The simplest form of nickel catalyst is made by suspending nickel formate in an oil, generally a vegetable oil of the type to be hydrogenated, and heating the mixture to about 300° F. At that temperature, the organic part of the nickel salt decomposes, with the formation of very finely divided metallic nickel. In another method of preparation, an aluminum-nickel alloy is decomposed with caustic soda solution, which dissolves the aluminum in the alloy and leaves the nickel in finely divided form. After all of the alkali and salt have been washed out, the nickel is suspended in oil and dried. It is then ready for use. In other methods, various compounds of nickel (such as nickel hydroxide or nickel carbonate) are precipitated on diatomaceous earth, the mixture is dried and ground, and the nickel compound is reduced at a high temperature with gaseous hydrogen, after which the finely divided nickel is added to the oil.

Commercial vegetable-oil hardening plants use tremendous quantities of pure hydrogen. Many manufacture their own hydrogen. Where electricity is cheap, hydrogen can be produced by electrolyzing a dilute solution of caustic soda. Oxygen is a byproduct of the process, and it is usually collected, compressed, and sold in steel cylinders.

The steam-iron process of manufacturing hydrogen is the one most widely used. In it, water gas is passed through a bed of hot iron ore. The water gas reduces the ore to metallic iron. Steam is passed through the reduced iron, reoxidizing the iron to iron oxide and liberating hydrogen through simultaneous reduction of the water (steam). The oxidation-reduction cycle is repeated over and over.

Other processes for producing hydrogen include the water-gas catalytic process and the hydrocarbon-reforming process. In the latter process, natural gas, or hydrocarbons from other sources, are cracked catalytically in the presence of steam to produce carbon dioxide and hydrogen. The carbon dioxide is separated from the hydrogen by chemical means. In the water-gas catalytic process, steam is passed over hot coke to produce a mixture of hydrogen and carbon monoxide. The carbon monoxide in the mixed gas is converted to carbon dioxide and hydrogen by another catalyzed reaction with steam.

All commercial hydrogenation of vegetable oils in the United States is carried out by the batch process in tall, gastight, cylindrical vessels known as converters. The converters, which have a capacity up to 30,000 pounds of oil, are equipped with heating and cooling coils, mechanical agitators or other mixing devices, and a device for distributing the incoming hydrogen through the oil.

The previously refined and bleached oil is mixed with a small amount of catalyst (0.05 to 0.50 percent nickel) and pumped into the converter. Then the free space above the oil is evacuated, agitation is started, and steam is introduced into the heating coils. When the desired temperature is reached (generally 200° to 400° F.), heating is stopped, and hydrogen is introduced and allowed to build up a pressure of 10 to 75 pounds per square inch above that of the atmosphere.

Hydrogenation is an exothermic reaction—that is, heat is generated in the

catalyst-oil mixture as soon as the reaction commences. If the hydrogenation temperature is to be kept constant, the oil is cooled as the reaction proceeds. In some instances, the temperature of the oil is allowed to increase; if it reaches an unsafe level, hydrogenation is interrupted temporarily. When the desired degree of hardening has been attained, the flow of hydrogen is stopped, the charge is cooled, and the catalyst is removed from the oil by filtration.

The point at which hydrogenation is discontinued depends on the type of product desired. For instance, if an oil is intended for use in margarine, just enough hydrogen is added and conditions are employed to make a fat which is semisolid at room temperature but liquid at body temperature. For the production of shortenings, the oil may be hardened to lardlike consistency, or it may be hardened completely to a material which melts at 140° F. and is glasslike at room temperature. The completely hardened material is blended with unhardened oils to produce so-called compound types of shortenings.

The melting point of a liquid fat is very sensitive to the addition of hydrogen. The melting point of a simple fat that contains only triolein can be changed from 41° to 161° F. by the addition of only 0.68 percent of hydrogen, which is the amount required for complete saturation of all the carbon-to-carbon double bonds. A variety of intermediate melting points can be obtained by smaller additions of hydrogen.

In the production of a semisolid, or plastic, fat, the amount of hydrogen added is the first consideration, but also of importance are the conditions under which the hydrogenation is conducted. The temperature, hydrogen pressure, type of catalyst, concentration of catalyst, and degree of agitation of the charge all influence the manner in which hydrogen combines with the oil.

Deodorization is the last processing step in the production of edible vegetable oils before packaging them for

shipment to the consumer. Its primary purpose is to remove all undesirable odors and flavors. Several incidental benefits are had by deodorization. For example, it destroys any oxidation products present in the oil, thereby increasing the resistance of the oil to rancidification. Also, it removes traces of free fatty acids, which are themselves odorless and tasteless, but, if allowed to remain in the finished product, would lower the temperature at which the oil would begin to smoke when used in frying. Finally, it further reduces the color of the oil through decomposition of some of the pigments that remain after refining and bleaching.

Odors in processed, but undeodorized, fats and oils include those from the original crude oil, those resulting from breakdown of the oil itself, and those that develop during refining and bleaching. Refining and bleaching induce traces of strong, characteristic odors, particularly odors characteristic of the bleaching earth used. The quantity of odoriferous components to be removed from a properly processed oil is usually less than 0.1 percent. The chemical nature of the compounds is not completely known, but they include derivatives of the fatty acids, as well as aldehydes and hydrocarbons.

In deodorization, the oils are held under a vacuum and heated to temperatures that will drive out the odorous compounds without injuring the oil itself. Meanwhile, steam is blown through the oils to carry off the volatile compounds.

Deodorization is actually an application of low-pressure steam distillation, often employed to separate compounds of very low volatility from others having still lower or no volatility.

The physical laws governing this form of distillation make it possible to predict, among other things, that the time required to deodorize a batch of oil at a fixed temperature and steaming rate is directly proportional to the amount of oil being deodorized, directly proportional to the absolute pres-

sure at which the operation is conducted, inversely proportional to the volatility of the pure odoriferous substances, and directly proportional to the logarithm of the ratio of initial to final concentration of the volatile substances in the oil.

Deodorization is usually carried out in a closed, insulated, vertical steel tank that holds 10,000 to 30,000 pounds of oil. The lower section of the tank is provided with a network of coils for introducing steam. The upper part is equipped with baffles to trap and return any oil droplets entrained by the vapor leaving the tank.

Equipment for producing the vacuum required for deodorization generally consists of multiple-stage steam ejectors connected to a barometric condenser. Such an apparatus is satisfactory for removing the condensable vapors and simultaneously keeping the pressure in the deodorizer below 0.12 pound per square inch absolute, which is a common and acceptable pressure in commercial deodorization.

Special equipment must be provided for heating and maintaining the required temperature of the oil. Steam is ordinarily not available at pressures high enough to provide the necessary temperatures (400° to 500° F.). In an early method the oil was continuously circulated between the deodorizer and a system of tubes heated by direct heat. In an improvement on the method, mineral oil is heated and circulated through coils in the deodorizer.

The most modern method, however, utilizes the hot vapors of a high-boiling mixture of two organic compounds. The vapors of this product, which is called Dowtherm, supply the necessary heat by condensing in the coils of the deodorizer.

Batch deodorizers have several undesirable features. The oil in the vessels is several feet deep, thus causing a pressure gradient through the oil so that not all of it is deodorized at the low pressure existing above the oil. Also, the oil must be kept at a high temperature for an undesirable length of time (1 to 6 hours) to complete the deodorization.

Continuous deodorizers, which avoid the defects inherent in batch deodorizers, have been developed. A counter-current flow of oil and steam is achieved in them. The continuous units, which operate at the same temperatures and pressures as batch deodorizers, make use of a system of shallow trays. The oil is deodorized as it flows downward from one tray to the next while the steam travels upward through the thin layers of oil. The deodorized oil is collected at the bottom of the deodorizer and is continuously removed through a suitable trap. Meanwhile, an equal amount of undeodorized oil enters the top of the deodorizer.

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TEMPÉ, a staple food of the New Guinea Indonesians, is made by fermenting soybeans wrapped in banana leaves. A special kind of mold, a strain of *Rhizopus oryzae*, is used. During the Japanese occupation of New Guinea, the mold was lost. Without it, the natives would not eat the soybeans imported to feed them. The mold was returned to New Guinea by air mail from Surinam, after it was learned that Javanese laborers there were cultivating it.—Lewis B. Lockwood, Northern Regional Research Laboratory.