TABLE VI
Yield, Moisture, and Fat Content of Carbohydrate Meal and Protein

	Wet product		Dried product		
	Weight	Moisture	Weight	Moisture	Fat
Carbohydrate meal	(lbs.)	(%)	(lbs.)	(%)	(%)
Range	53.9–84.4	69.0–79.0	12.2–19.0	4.8–12.4	5.5–10.0
Mean ± S.D.	60.9 ± 7.2	72.1 ± 3.2	17.0 ± 1.8	7.4 ± 2.2	7.1 ± 1.3
Protein					
Range	37.0–52.7	47.0–59.0	17.5–25.3	1.7– 7.5	4.3–18.1
Mean ± S.D.	49.2 ± 4.1	53.9 ± 3.2	22.7 ± 1.8	3.5 ± 1.6	9.9 ± 2.9

tent of 0.01%. The over-all recovery of 631 lbs. of oil from 1,500 lbs. of peanut containing 48.8% oil is equivalent to 85% recovery. The main reason for this low recovery is the low efficiency of the separation process. The "skim milk" contained an average of 0.6% fat, equivalent to a loss of 4.8% oil on the weight of the peanut processed. The separator efficiency should therefore be considered for further investigation.

Samples of oil stored in air-tight, 4-oz. tin cans at room temperature (75–90°F.) over a period of 12 months were organoleptically evaluated and found to be acceptable. The peroxide value of the total oil (Skipin oil + Separator oil) increased from an initial value of 2.1 to 6.3 (millimoles of peroxide per kg. of fat) and the F.F.A. from 0.16 to 0.23% during the period of storage.

Protein. Protein is the other important product of the process. The quality of the protein had to be sacrificed in these trials to arrange a suitable working schedule. For example, the Skipin process, making use of alkaline water, was carried out the previous afternoon; the paste was drained over-night and dispersed next morning. It is not known how much this long contact with alkali affects the quality of the protein. Again the wet protein was dried at 60°C. (140°F.) in order to increase the drying rate. The extent to which the different operations of the process affect the protein also needs study. In the present series of experiments nearly 70% of the original nitrogen in the peanut was recovered as protein. The protein obtained was of greyish yellow color and had a high fat content; a specimen of the mixed lot of protein on analysis gave moisture 6.2%, fat 9.0%, protein 85.0%, and ash 0.4%. As pointed out earlier, a more efficient separator not only will considerably increase the oil yield but also at the same time reduce very much the fat content of the protein and improve the keeping quality.

Carbohydrate Meal. This fraction was obtained as small lumps which had a grey-brown color on the surface. When quickly dried, the product was practically odorless and bland. The drying process offered no difficulties. The ground meal had a slight dull color and was analyzed as follows: moisture 12.0%, protein 16.2%, fat 6.1%, starch 41.6%, crude fiber 10.3%, ash 6.0%, unaccounted portion 7.8%.

Table VI gives the yield and moisture and fat content of the carbohydrate meal and protein.

Summary

Bench-scale experiments were carried out on the processing of peanut by a new method. The decuticled kernels were pasted, and the paste was subjected to the Skipin process to recover approximately 30% oil; the residual paste was made into a dispersion at 10.0 pH and clarified to get a carbohydrate meal (15.7% moisture-free); the clarified dispersion was centrifuged to obtain another 12% fat and the remaining dispersion was acidified to get the protein (21.9% moisture-free).

Fifteen batches of 100-lb. (45.4 kg.) each have been processed, and the reproducibility of the yields has been ascertained. The scope for increasing the oil yield and for improving protein quality is discussed.

Acknowledgment

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Continuous Low-Temperature Rendering Process

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THE AIM OF THIS PAPER is to describe the Centriflow Continuous Low-Temperature Rendering Process which produces lard and tallow, high in quality, light-colored, and low in free fatty acids. Fat recoveries obtained by this process are very high.

Fat in animals is always contained within the walls of individual cells, which are held together in a structure or system by muscles, sinews, or connective tissues. The extraction of fat from this structure by the use of heat is termed rendering. Vibrans (2) and later Dormitzer (1) have reviewed the earlier methods of rendering, such as wet rendering and dry rendering.

In this process the continuous method becomes practical by carefully combining both mechanical and heat rendering methods, followed by special types of centrifuges. These features allow a minimum retention time of the fat within the system and the application of the lowest practical temperatures required to complete the rendering. Product degradation is reduced to a minimum. Fat yields are extremely high.

Basic Steps

The process can be broken down for general purposes of description into three basic steps as follows.

Mechanical Treatment. Application of the proper amount of mechanical treatment serves two main

[1] Presented at the annual meeting, American Oil Chemists' Society, Memphis, Tenn., April 21–23, 1958.

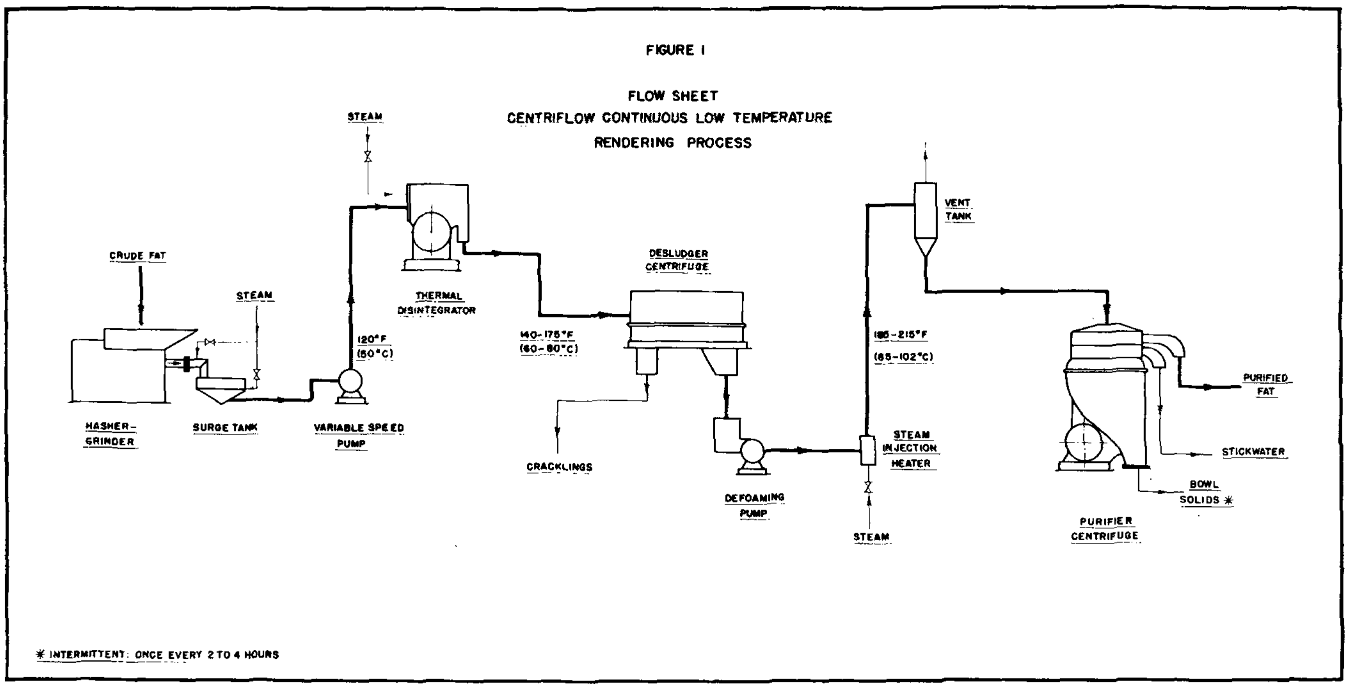

FIG. 1. Flow sheet for Centriflow Continuous Low-Temperature Rendering Process.

purposes: a) it breaks down the over-all structure of the fatty tissue to a degree of fluidity which might be called a slurry, and b) a special type of mechanical treatment actually breaks a great many of the cell walls to release the major portion of the fat.

Heating. For simplicity, ease of control, and the elimination of local over-heating, direct steam injection is the heating method used almost completely throughout the process. Intimate contact of the direct steam, during the agitation produced by mechanical treatment, allows rendering at the lowest possible temperature.

Centrifuging. The fluidity produced so quickly by both of the above types of processing makes it easy to apply the usual continuous processing techniques and especially adapts the material to the unit operation of centrifugation.

Two different types of centrifuges are used. The first removes the greater portion of the proteinaceous solids or cracklings as a very thick slurry while the second, which operates at a high temperature and with a shorter retention time, removes the last traces of solids and water to produce a brilliant, light-colored, high-quality fat.

Plant Operation

It is important that a fat-rendering plant be able to treat materials from different sources. It is equally important that materials of varying qualities and in different states of condition can be processed. In spite of these differences it must be possible to produce the highest quality of product consistent with the quality of the raw material. The flexibility of this continuous process allows the accomplishment of all these objectives. A schematic flow sheet is shown in Figure 1. The operation may best be described by following the process flow from raw material on through to the final product. The raw material is continuously charged to the hasher-grinder, where it is reduced to a uniform size and fluidized to a thick slurry.

The hashed fat, discharged through the grinding plate of the hasher, is immediately heated in the discharge pipe with direct and/or indirect steam, depending upon the nature of the material. Temperatures at this point are generally in the neighborhood of 120°F.

Next the mass, *via* an air-tight connection, drops into a surge tank. This heated tank, of approximately 150-gal. capacity, is used as a means of keeping a constant supply of heated raw fat available for the following steps in the process. Now in completely liquid form, the fat stream is transferred by a variable-speed, positive displacement pump to the thermal disintegrator. Direct steam injection increases the temperature to 140–185°F. It is in this unit that the application of both heat and mechanical rendering completes the break-out of the fat from the cells.

From the disintegrator the rendered fat stream feeds by gravity directly into the De-Sludger. This machine, a horizontal conveyor type of centrifuge, removes the cracklings from the fat and delivers a fat-water mixture, containing a small amount of solids, in a form suitable for final purification. The cracklings discharged from the De-Sludger are low in fat and water content and are thick enough to be carried away on a belt or helical conveyor.

The fat-water mixture from the De-Sludger flows by gravity to a defoaming pump. This unit discharges a defoamed fat stream through a direct steam heater where the temperature is raised to 200–215°F., depending upon the nature of the material being handled. From this heater the fat goes directly to the overhead vent tank and then to the final centrifuge.

Contact time of the fat, and its small amount of suspended proteins at this temperature, are maintained as short as possible. Pipelines are short, the heater is located near the final centrifuge, and the contact time is only a few seconds.

The final centrifugal purifier separates the fat from the water and the small amount of suspended solids as the final step in the process. The type of centrifuge used at this location will vary, depending upon the plant's hourly capacity.

Equipment Details

The hasher-grinder, used in most of the Centriflow plants, is a self-feeding unit with powered screws which drag and force the lumps of raw fat down into the helical hasher blades and through the discharge or grinding plate. Knives rotating against the grinding plate complete the crushing and hashing of the crude fat. As is common in units of this type, holes of different size in the plate can be used to vary the hashing or grinding action. These holes are usually from $\frac{5}{16}$ to $\frac{9}{16}$ in. in diameter. This particular model has the direct heating device attached to its outlet.

The thermal disintegrator is shown in Figure 2. It consists of cylindrical steel blades, which rotate at high speed within a specially designed casing. It is provided with a steam connection for the direct injection of heating steam and with a quick opening cover for cleaning purposes. Relatively low-pressure steam can be injected into the fat to attain the required degree of heating.

The design of the disintegrator blades produces a beating action within the fat mass so that the particles of sinew and tissue are not materially broken down into smaller pieces. The blades merely beat the tissues to the point where internal cell walls are ruptured to allow release of the fat from the structure.

The De-Sludger, fed by the disintegrator (Figure 2), is a machine designed especially for the removal of cracklings from a fat-stickwater mixture. Inside its rotating drum the cracklings are withdrawn from the liquid by a rotating screw conveyor and discharged separately from the fat-water mixture. The relationship between the speed of the rotating conical bowl and the conveyor has been carefully selected to give the maximum degree of separation and dryness of the removed cracklings.

One type of centrifuge used for the final separation or purification of the fat is shown in Figure 3. This machine is termed a self-opening bowl unit in which the purified fat and the stick-water are continuously separated and separately discharged. That portion of the solid material which collects in the outer space of the centrifuge bowl is discharged periodically and may be mixed with the cracklings. This discharge may be performed manually or by an automatic timer that energizes a control valve. This timer control actuates a hydraulic mechanism which stops the feed, opens the bowl shell wall for the discharge, closes the bowl, and turns on the feed. The entire operation of shooting the bowl requires only a few seconds.

FIG. 2. Centriflow rendering plant with De-Sludger in center.

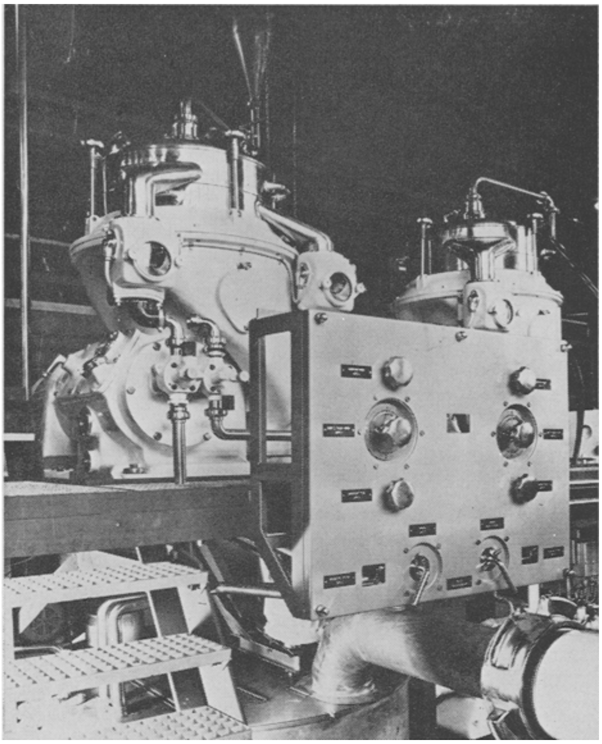

FIG. 3. De Laval self-opening lard purifier.

Another type of centrifuge used principally in the plants of larger capacity is the Hermetic nozzle-type. This unit discharges the stickwater along with the suspended solids continuously through a set of nozzles located in the periphery of the bowl wall. This centrifuge has been specifically designed for this operation. The clarified fat is continuously separated from the suspended water and solids, discharged into the closed upper covers, and piped to final storage.

Technical Data

The plant operates continuously at rates varying from 1,000 lbs. per hour upwards to 30,000 lbs. per hour, depending upon the number and size of the equipment units. At the most recent installation the rate is 30,000 lbs. per hour of raw feed on day of 8–10 hrs.

When the plant is shut down, the fat remaining in the pipelines and machines is flushed out with water and the system is then drained; the final centrifuge separates this fat from the flush water. The plant is then cleaned by recirculating a detergent solution, rinsed with hot water, and sterilized with steam at the end of a day's operation.

There are presently some 20 Centriflow installations

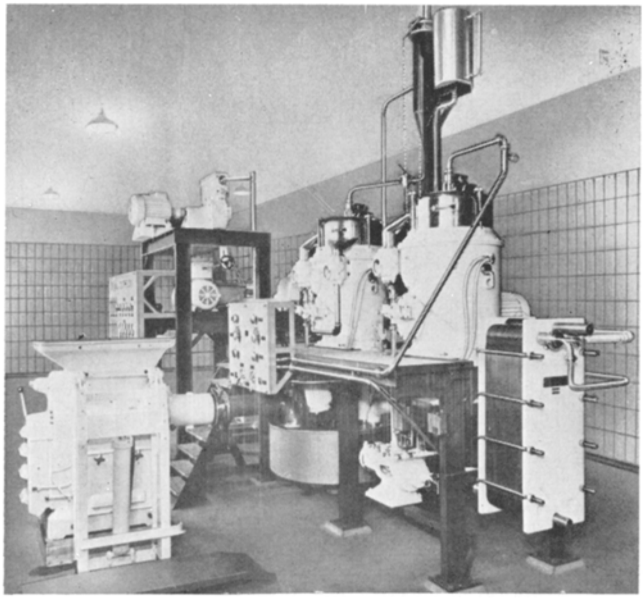

FIG. 4. Typical 8,000 p.p.h. Centriflow rendering plant.

throughout the world, either installed and operating or under construction. Figure 4 shows a typical installation of approximately 8,000 lbs. per hour of raw-fat capacity. This installation is extremely compact and automatized. The hasher in the foreground is equipped with a hydraulic lifter for dumping raw fat into the feed hopper. The raw fat enters the hasher and comes out a purified, cooled fat which discharges from the plate heat-exchanger shown in the right foreground.

Numerous data have been obtained from the many installations when operating on various types of fats producing lard and tallow. This continuous process gives an extremely high yield and a high-quality fat. Table I gives material balance data for an average rendering plant. For an easy means of calculating, a 1,000-lb. basis was used for all data.

The lard fat in this case contained 84.1% fat in the raw material while the tallow stock contained 76.5% fat; the recovery of fat in both cases was 99.5%.

Recent information received from Denmark, where the purified lard from a Centriflow plant was rated by an impartial research institute, gave the following results: peroxide value 0.2 me, free fatty acid 0.08%, and total water 0.16%. Fat content in the cracklings was 4.0%. It was further stated by this same research institute that the Swift Stability Test for average Danish fat was 3.9 hrs. while the Centriflow fat tested 7.0 hrs. There were no antioxidants added in either case.

TABLE I
Test Results from a Centriflow Rendering Plant
(Basis: 1,000 lbs. Raw Material)

	Lard	Tallow
Total fat content of raw material	84.5 %	76.5 %
Weight of final products		
Recovered fat	841.0 lb.	761.0 lb.
Cracklings	73.8 lb.	73.0 lb.
Stickwater[a]	174.2 lb.	253.0 lb.
Total	1089.0 lb.	1087.0 lb.
Cracklings	73.8 lb.	73.0 lb.
Solids	28.7 %	28.4 %
Water	67.2 %	67.8 %
Fat	4.1 %	3.8 %
Fat lost	3.03 lb.	2.77 lb.
Stickwater	174.2 lb.	253.0 lb.
Solids	3.8 %	1.9 %
Water	95.6 %	97.4 %
Fat	0.6 %	0.7 %
Fat lost	1.04 lb.	1.77 lb.
Total loss of fat	4.07 lb.	4.54 lb.
Fat Yield	99.5 %	99.5 %

[a] Contains the condensate from direct steam heating.

Conclusion

It has been shown that the Centriflow Animal Fat Process will continuously render various types of raw fatty tissue and in every case produce a high-quality fat with a high yield. The fat produced shows practically no increase in free fatty acids during processing; the taste is neutral, the color light, the water content extremely low, the insoluble content nil, and the yield generally higher than 99% and quite often over 99.5% of the fat content of the raw material.

Summary

A new process for rendering animal fat employing low temperature and short contact is described. This system gives an extremely high yield of quality fat and at the same time produces cracklings of low fat-content.

The individual pieces of equipment are shown along with their functions, which when combined into the continuous process make for a rendering operation of high efficiency.

Plant operating information and material balances combined with flow sheet and actual plant photographs illustrate the efficiency, ease of operation, and compactness of the Centriflow Animal Fat Process.

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Tocopherol Oxidation in Fats. Hydrogenated Soybean Oil[1]

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STUDIES on the antioxidant behavior of tocopherol have been generally confined to lard primarily because natural tocopherols are essentially absent in this fat. Soybean oil is almost never used for antioxidant evaluations because experience has shown that it does not respond to antioxidant treatments. This lack of response is attributed to the high content of natural tocopherols (0.15%) in soybean oil (14). Few studies have been made on tocopherol loss in autoxidizing soybean oil, hydrogenated soybean oil,

[1] Presented at the 49th annual meeting, American Oil Chemists' Society, Memphis, Tenn., April 21–23, 1958.