An Alkali Rendering Process for Lard and Other Animal Fats *

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SEVERAL years ago the Kroger Company was in the meat packing business and, like other packers, had a surplus of lard. In cooperation with the Ohio State University Research Foundation, a study of what might be done to turn surplus lard into profitable merchandise was undertaken. After some exploratory investigations it appeared that lard and beef fat as currently produced might not lend themselves too easily to further profitable processing because some of the objectionable characteristics in lard and beef fat—such as low smoke point, color, odor and flavor — seemed to result from orthodox rendering methods. Examination of native beef and pork fat obtained by extraction with various solvents or by mechanical means tended to support this hypothesis. Accordingly, it was decided that our study should be directed toward finding a rendering method which would yield a pork or beef fat that would have greater acceptance in the edible fat and oil market.

Essentially native animal fatty tissue consists of three parts—liquid fat, aqueous tissue fluids, and solid structures composed of protein. Therefore, the desired rendering operation should separate the fat from other structures without imparting a high free fatty acid content and undesired color, odor, and flavor qualities to the finished fat.

Since the prolonged cooking of conventional rendering methods apparently causes deterioration in the quality of the native fat, the simplest theoretical method of removing the fat would be by mechanical means. This method was tried but the practical difficulties of commercial application led to another approach. If the non-fat tissue solids could be caused to dissolve in the aqueous phase the rendering problem would be simplified to the separation of a liquid fat phase from a liquid aqueous phase. This is the basis for the lard and beef fat rendering process to be described.

The process will be discussed with respect to lard for the most part since beef fat rendering is quite similar.

The tissue proteins of animal fats may be hydrolyzed to water soluble substances with enzymes, or with various hydrolyzing reagents. Without going into details, experiments indicated that sodium hydroxide was the most promising reagent for dissolving non-fat tissue solids.

The early experimentation was done using back fat with skin on, ground twice through a 1/8" plate. It was found that 0.4% (0.1 normal) sodium hydroxide was strong enough to dissolve most of the tissue solids when mixed two parts of ground fat to one part of the sodium hydroxide solution and warmed one hour on a steam bath. On centrifugation the fat separated easily and the mixture stratified as indicated in Figure 1.

A somewhat better separation resulted when 0.8% sodium hydroxide and 5% salt was used for tissue digestion. For batch centrifugation these concentrations of alkali did very well and the lard so rendered was very satisfactory. However, this digestion mixture did not separate easily on continuous centrifugation. This was particularly true of large scale experiments using the No. 6 Sharples supercentrifuge. The difficulty was that the fat would be separated containing some emulsion which was not easily broken.

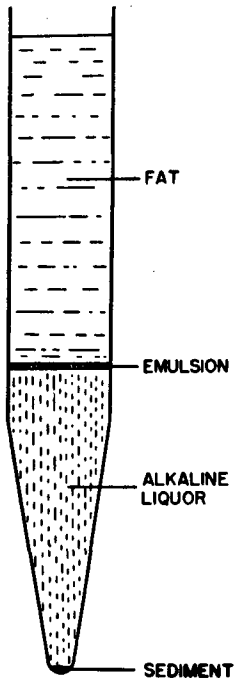

FIG. 1. Stratification obtained by centrifuging a mixture of ground fatty tissue and aqueous sodium hydroxide after 1 hour digestion at 85-95° C.

Further work at this point indicated that the emulsification might be due to incomplete digestion of the tissue solids. The emulsion layer of Figure 1 seemed to be caused by very fine solid particles. When more complete digestion was effected by stronger alkali this layer tended to disappear. A study was made of the strength of alkali necessary to dissolve more of the tissue solids without saponifying the fat. For one hour digestion at 85 to 95° C., it was found that sodium hydroxide concentrations above approximately 2% caused troublesome saponification and emulsification, while below 2% essentially no saponification resulted. Accordingly 1.75% sodium hydroxide was found to be very satisfactory for reducing the tissue solids to water soluble substances and to give a mixture that could be centrifuged easily to give a superior product.

At this stage of the investigation the lard rendering process was: Grind raw fat tissue through a 1/8"

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plate, mix with about ½ its weight of 1.75% sodium hydroxide solution, heat with atmospheric steam with gentle agitation to 85-95° C., for 45 minutes to 1 hour, separate the fat by centrifugation, wash the centrifuged fat with water at 90 to 95° C., twice, recentrifuging each time. The resulting fat was ready for drying, bleaching, and deodorization, if desired.

Further experimentation led to refinements which permitted faster centrifugation and cleaner separation. Among these were the use of 2 to 5% salt as well as 1.75% sodium hydroxide in the alkaline digesting solution, the use of 2 to 5% salt solution as the first wash; water as the second wash and if desired, a third wash with 0.1% sulfuric or phosphoric acid. The acid wash improved the flavor and odor if the fat was to be used without deodorization. The efficiency of the first salt wash was improved still further by using salt containing a small amount of calcium chloride.

The resulting lard had the following characteristics: free fatty acid, 0.01 or less; smoke point 450-480° F.; color (Lovibond), about 2 yellow and 0.3 red; odor, slight lard but no cooked odor; and keeping time, 5 to 7 days at 70° C. in air. After deodorization there was no odor; the color was about 1 yellow and 0.3 red; smoke point and keeping quality were essentially unchanged; and there was little or no flavor reversion. The keeping quality of the alkali rendered lard was somewhat better than conventional lards but was of the same order of magnitude. For prolonged shelf life the use of antioxidants was necessary. This lard responded to the various antioxidants in the same manner as ordinary lard and presented essentially the same problems on keeping quality.

Before going further in describing the process it might be well to enumerate some manipulations which may either facilitate or complicate the process. The raw fat tissue should not be cooked either by steam injection or by dry heat prior to addition of the alkali. In other words the protein material should not be heat denatured prior to alkali treatment and subsequent heating. To the cold ground fat the hot aqueous alkali should be added. Heat should be applied using atmospheric steam in a jacketed tank, with gentle stirring until the fat is melted and the tissue and alkali are dispersed. For the last 15 to 20 minutes of the digestion period the mixture should not be stirred. This facilitates centrifugal separation. The fat tissue to be rendered should be as fresh as possible since the older the raw fat is, the more difficult it is to render, in that centrifugation is more difficult due to the higher soap concentration in the alkaline liquors. This is apparently due to the increased fatty acids resulting from natural enzymic lipolysis. Further, the higher free fatty acid of several-day old raw fat reflects itself in slightly diminished yields of neutral fat. If processing temperatures above 100° C. are employed, pressure cooking must be used and these higher temperatures promote saponification. The process may also be speeded up by draining off the separated alkaline liquor containing any small amount of undissolved skin or other heavy tissue fragments. This step is not necessary but it facilitates the process by cutting down the total fluid to be centrifuged and reducing the frequency of centrifuge bowl cleaning.

For all work Sharples Supercentrifuges equipped with separator bowls were used. Laboratory experiments were run using the small laboratory model operating at 25,000 r.p.m. which approximates the centrifugal force developed in the No. 6 commercial centrifuge. Ring dam No. 9 was used in the small centrifuge while No. 35 or No. 36 were found satisfactory for the large machine. The centrifuges were gravity fed—pumping was less satisfactory.

Alkali digesting solution containing 1.75% sodium hydroxide was used in most studies. In some cases 2% to 5% salt was added to facilitate separation but it is not essential. If low salt concentrations were desired in the alkaline liquor containing the dissolved tissue solids, centrifugation rates could be increased if 75 to 80% of the original sodium hydroxide were neutralized with hydrochloric acid prior to centrifugation. The quality of the rendered fat was unimpaired by such treatment. If the free fatty acid was desired in the resulting rendered fat all of the alkali may be neutralized before separation of the fat from the aqueous phase.

The amount of alkaline digesting solution required for the most effective rendering depends on the non-fat tissue solids present in the raw fat. For shoulder and ham facing fat about 50% of the raw fat weight as added digesting solution gave satisfactory results. For back fat or "skin-off" ham fat 40% was sufficient, whereas leaf fat required only 20 to 25% of its weight as alkaline digesting solution.

The alkaline liquor resulting from the rendering process contained protein derivatives from hydrolysis of non-fat tissue solids, soaps from the free fatty acid of the original fat or from whatever saponification of neutral fat there was during the processing, practically no neutral fat and a very small amount of ether soluble substance which was insoluble in acetone and appeared to be phospholipid. The protein hydrolysate may be separated into an acid (pH 3) precipitable fraction which was soluble in 70% ethanol and 70% acetone and another fraction not precipitated by acid but precipitated by saturated ammonium sulfate. This latter fraction displayed characteristic solubilities of proteoses. The amounts of these protein derivatives obtained depended on the amount of protein tissue solids of the original fat. The yields of the acid precipitable fraction on original raw fat basis was 0.2-1.7% and for the acid soluble fraction 0.2-3.0%. The higher percentages were characteristic of ham faces with skin on while the lower ones resulted from leaf fat.

In the laboratory execution of the alkali rendering process according to the foregoing remarks, about 6,000 to 8,500 grams of ground raw fat was used. To this the appropriate amount of alkaline digesting solution was added and the whole mixture heated by atmospheric steam. During the heating the mixture was gently stirred until all the fat was melted and the whole became a soupy mass. The mixture was stirred about every 5 minutes until 45 minutes had elapsed. Heating was continued for another 15 minutes without agitation and the hot mixture was then separated into fat and aqueous phases by centrifugation. The fat was washed with about 25% of its weight of hot salt solution and recentrifuged. The fat was again washed with hot water. A third wash with dilute acid or hot water was carried out; the resulting fat was then vacuum filtered while hot,

using a filter aid, and the filtered fat was clear and had the characteristics noted above. It was then ready for deodorization or other use. Since relatively small samples of raw materials were used, direct measurement of yield was without much meaning. Ham fat yielded 72-82%; back fat, 79-90%; and leaf fat 89-93%. These figures include centrifuge bowl drainings since such losses are not inherent in the process. Practically no neutral fat was lost in the process so it appears that the yields noted represent almost all of the fat in the raw material.

The alkali rendering of beef fat was carried out in the laboratory in much the same way as with the pork fat. The beef fat was of superior quality compared to that produced by ordinary rendering. This was particularly true with respect to color which was a rich light yellow to orange, and to flavor which was much more bland. Somewhat more alkaline digesting solution was used for rendering beef fat than for lard since in the small laboratory operation the aqueous liquors tended to gel immediately after centrifugal separation due to cooling at the discharge end of the centrifuge. This gelation was observed in the case of lard only after the alkaline liquors cooled somewhat after discharge and, therefore, was not bothersome.

Laboratory experimentation indicated that the process had commercial possibilities but war conditions prevented the construction of a pilot plant. However, it seemed advisable to try to evaluate the process in some large scale manner in order to determine the future course of study. Through the generous cooperation of various firms, numerous experiments were conducted using commercial size equipment simulating a pilot plant. However, several details of operation could not be investigated but some of the major questions were answered.

The rendering process worked out quite satisfactorily when carried out in a manner similar to the laboratory but on a larger scale. A Roto-cut machine can be used as well as a screw type plate grinder for comminuting the native fat. Centrifuges should be gravity fed rather than pump fed for the primary separation. Digesting solutions and washes were as in the laboratory size runs.

Experiments were set up to try to answer these questions: Would the process work on a larger scale? If so, what would be the through-put rate of the No. 6 Sharples Supercentrifuge in the primary separation and in the washes? How often would the centrifuges require cleaning? What would be the yields (or processing losses)? These and other questions may be answered from the following data, Table I and Table II, obtained in some of the experiments.

The equipment used is shown in the schematic diagram, Fig. 2.

The data on yield and losses indicate an excellent recovery of all available fat and from this standpoint the process was quite satisfactory. The undissolved solid matter (Fig. 1) which represented skin fragments etc. collected in the centrifuge bowl necessitating periodic bowl cleaning. Assuming that a bowl may carry 8 pounds of solid matter without impairment of efficiency, these data indicate that 2400 to 5000 or more pounds of raw fat tissue may be processed without centrifuge cleaning. It should be pointed out that these are minimum figures since in practice stratification of the alkaline digestion mixture would permit draining off of a large amount of the aqueous phase containing most of the undissolved solids. This procedure was not followed in our experiments since it was desired to ascertain the highest frequency of bowl cleaning that might be necessary. In the tests reported, centrifugation rates were not a primary part of the study as long as 1200 pounds of raw tissue could be handled per hour. This rate was considered the minimum practical rate. However, in later tests, as indicated in Table I, considerably higher rates were attained without sacrificing efficiency; so a conservative estimate on the operating rates in commercial practice would be at least 1500 to 1600 pounds of raw tissue per hour per centrifuge.

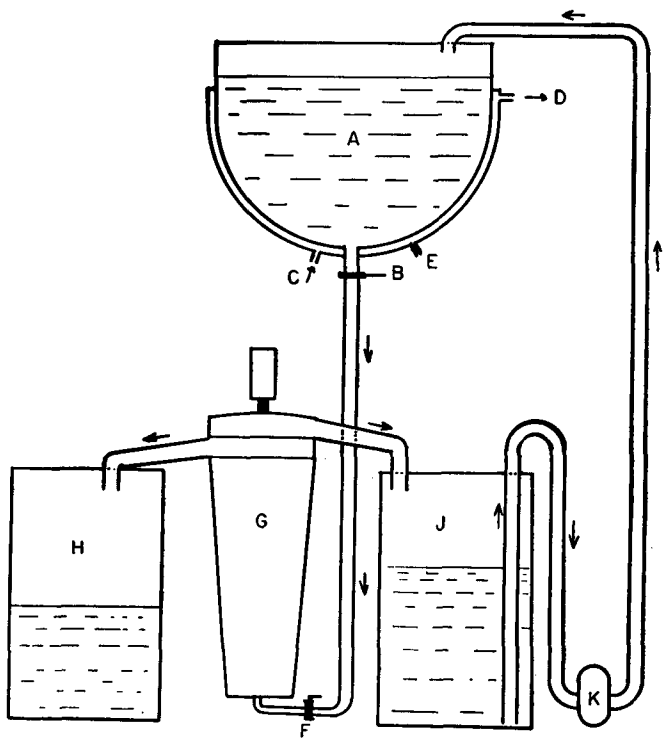

FIG. 2. Diagram showing layout of equipment for the large scale experiments: A, 100-gal. steam jacketed kettle; B, gate valve to centrifuge; C, steam inlet; D, steam outlet; E, condensate outlet; F, centrifuge gate valve; G, No. 6 Sharples supercentrifuge equipped with separator bowl; H, 55-gal. drum for collecting all aqueous liquors; J, 55-gal. drum for collecting fat; K, positive action pump to lift rendered fat from J to A for washing.

The foregoing discussion concerning the rendering process itself may be summarized by reference to the diagram (Fig. 3) of a proposed alkali rendering operation designed to handle in an 8-hour working day the edible beef and pork fat out-put from a packing plant killing 1100 hogs and 100 cattle per day.

This layout shows 2 grinders, 3 digesting tanks, 4 primary centrifuges, 3 centrifuges for each of 2 washes, and supply tanks for sodium hydroxide solution and salt solution. Not shown are the vacuum dryer, bleaching tank (if desired), filter, storage tank, deodorizer, and plasticizer. The requirements and arrangement of these items of standard equipment would depend on kinds of products produced.

A loss in color on deodorization was noted above; but if bleaching was desired, only a very light treat-

TABLE 1

Operating Data From Semi-commercial Application of Alkali Rendering Process

Run No.	Raw Material	Weight Raw Tissue	Net Yield	Est'd Losses[1]	Total Yield	% Yield	Digesting Solution[2]	1st Wash[3]	2nd Wash Water	Undissolved Solids Collected in Centrifuge	Centrifugation Rates Lbs. per Hour		
											Primary Separation Raw Tissue	1st Wash Fat	2nd Wash Fat
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Oz.*			
1.	Ham Fat	299	218	5	223	74.6	145	100	80	15.0	.....	.....	.....
2.	Ham Fat	294	214	10	224	76.5	145	75	65	16.0	1200	1200	1200
3.	Ham Fat	311	226	5	231	74.3	145	85	65	17.0	1200	1200	1200
4.	Ham Fat	318	229	8	237	74.5	153	85	65	18.0	1200	1200	1200
5.	Ham Fat	312	235	10	245	78.5	150	80	65	14.5	1200	1200	1200
6.	Back Fat	300	243	15	258	86.0	129	80	65	8.5	1200	1600	1600
7.	Back Fat	297	238	15	253	85.1	129	80	65	8.5	1350	1700	1800
8.	Back Fat	303	248	12	260	85.8	129	80	65	7.0	1500	1500	1500
9.	Back Fat	300	237	16	253	84.3	129	80	65	7.0	1800	1650	1900[4]

[1] These figures represent losses as handling losses (dripping, spilling, etc.) and centrifuge bowl drainings. These losses are not inherent in the process of alkali rendering. Proper equipment will minimize the former while commercial operations will eliminate the latter, since bowl drainings will be put back into production.

[2] Digesting solution was made by dissolving 1.75 parts sodium hydroxide and 5 parts salt in 100 parts of water. Total digestion time 1 hour. The temperature for last 30 minutes was 85°-90° C.

[3] First wash was with 5% salt solution which contained 0.03% calcium chloride.

[4] Maximum rate of delivery to centrifuge with available equipment.

ment was necessary. For example, 0.01% Special Filtrol produced an almost colorless fat.

The alkali rendered fats were very easily deodorized and flavor reversion was not noticeable. Almost a completely bland product was obtained after one hour's deodorization in an apparatus similar to that of Bailey and Feuge (1) operating at 200° C. and 0.01 mm. pressure. Only slight improvement was noticed after 4 hours' deodorization. For the pilot plant scale deodorization, 400 pounds of fat was heated to 400° F., and blown with 14 pounds of 420° F. steam per hour at a pressure of 3 to 5 mm. of mercury. Deodorization was carried on for four hours.

Plasticizing alkali rendered fats presented no problems different from ordinary lards judging from tests using a laboratory size Votator operating at 300 lbs./hr.

The alkali rendered fats were tested for possible disposition as domestic shorteners, commercial shorteners, and margarine bases with quite promising results.

Through the cooperative efforts of four plants in three cities a suitable amount of deodorized and plasticized alkali rendered lard was produced for modest consumer testing. Since the samples were six weeks in preparation they were somewhat below expected quality but they were tested anyway. Comparisons were made in four ways with 125 consumers participating in each test: (1) Undeodorized alkali rendered lard was barely preferred to general run steam rendered packer's lard; (2) deodorized alkali rendered lard was preferred in almost all cases when compared with general run steam rendered packer's lard; (3) domestic vegetable shortener was preferred over deodorized alkali rendered lards in a significant number of instances; (4) deodorized alkali rendered lard was preferred to high grade leaf lard currently on the market. The results were favorable to the alkali rendered lards in each case except (3) which was barely in favor of vegetable shorteners; however, the consumers' objections to the alkali rendered product were such that they could be easily corrected. Chi squares for each test were respectively, 4.1, 51.0, 6.0, and 14.6. Chi squares above 3.8 are considered significant and those above 6.6 highly significant.

Quite acceptable margarines were prepared on small scale from deodorized alkali rendered lard. Deodorized lard oil made a satisfactory salad dressing.

As a large user of commercial shorteners we investigated the use of deodorized alkali rendered pork and beef fat in compounding the various types of shorteners used in our bakeries. Highly satisfactory bread, doughnut-frying, biscuit and cracker shorteners were made. Considerable promise was evidenced

TABLE 2

Losses Inherent in Process[1]

Run No.	Total Weight Aqueous Liquors	% Ether Soluble Substance[2]	Ether Soluble Substance After Acidulation With Hydrochloric Acid[3]	Actual Loss, Et_2O Soluble Substance Found	% Based on Actual Fat	Actual Total Loss[3]	% Based on Actual Fat	Estimated Refining Loss Soap[4]	% Based on Actual Fat
	Lbs.			*Lbs.*		*Lbs.*		*Lbs.*	
1.	400	0.06	0.21	0.24	0.11	0.84	0.38	0.60	0.27
2.	400	0.14	0.36	0.56	0.25	1.44	0.64	0.88	0.39
3.	400	0.07	0.33	0.28	0.12	1.32	0.56	1.04	0.44
4.	350	0.12	0.36	0.42	0.19	1.26	0.53	0.84	0.35
5.	.....	.....	.....	.....	.....	.....	.....	.....	.....
6.	350	0.12	0.42	0.42	0.16	1.47	0.57	1.05	0.41
7.	350	0.23	0.56	0.80	0.30	1.93	0.75	1.13	0.45
8.	350	0.11	0.49	0.38	0.14	1.71	0.65	1.35	0.51
9.	300	0.12	0.46	0.36	0.14	1.36	0.54	1.00	0.40

[1] Losses inherent in the process represent refining losses—free fat acid of the original fat, lecithin, losses from saponification due to alkali, neutral fat dissolved in, emulsified in or occluded to the aqueous phases whether wash or primary digesting solution.

[2] Lecithin plus neutral fat.

[3] Total loss inherent in process.

[4] These figures represent free fatty acids whether present originally in tissue or resulting from saponification due to caustics used in process.

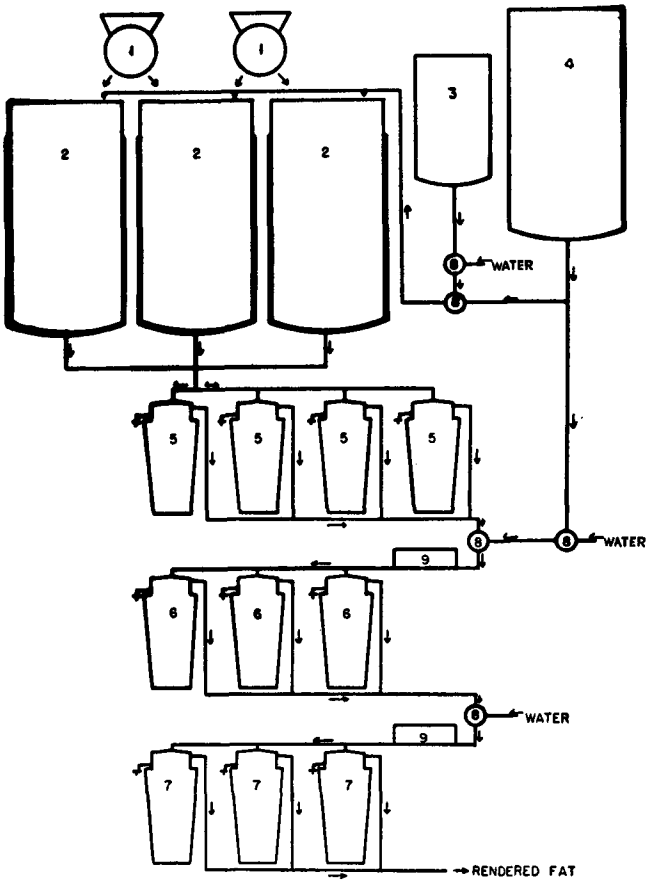

FIG. 3. Schematic diagram of suggested layout for alkali rendering operation for a packing plant killing 1100 hogs and 100 cattle per day: 1, two grinders; 2, three 1200-gal. steam jacketed digesting tanks; 3, 300-gal. supply tank for 20% sodium hydroxide solution; 4, 1200-gal. supply tank for 20% salt solution; 5, four primary centrifuges; 6, three centrifuges for first wash; 7, three centrifuges for second wash; 8, five proportioning and pumping devices; 9, two mixing and heating devices for the two washing operations.

in compounding high ratio cake shorteners from these fats although more work is needed in this direction.

In concluding this paper the author does not wish to leave the impression that the process and product just described are commercial realities. However, the results have been sufficiently promising to warrant preparation of patent application which are now pending. A somewhat similar process has been proposed for the recovery of fats and oils in the fishing industry, particularly by Anderson (2) who recovered oil from salmon offal. More work is required but these investigations indicate that alkali rendering may be practical and yield a high quality product in a competitive market. Events of the recent past have changed our company's policy with regard to meat operations; therefore, we are not planning to pursue these studies further but are taking this opportunity to describe our experiences to others.

Summary

An alkali rendering process for the production of edible animal fats has been described.

Laboratory and semi-plant scale experiments indicate that high quality edible lard and beef fat may be produced in a semi-continuous process.

Alkali rendered pork and beef fats are suitable for compounding into high quality domestic and commercial shorteners.

Acknowledgment

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Abstracts

Oils and Fats

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M. M. PISKUR and SARAH HICKS

THE POSSIBILITIES OF USING SPECIES OF PERENNIAL CUCURBITS AS SOURCE OF VEGETABLE FATS AND PROTEIN. L. C. Curtis (Univ. Connecticut, Storrs). *Chemurgic Digest 5*, 221, 223-4 (1946). A table gives a comparison between the composition and yield of soybeans, peanuts, and 3 species of cucurbits. No experimentation on these gourds has yet been made in the United States. The yield could be increased if the plants were cultivated or grown under more favorable conditions. At present, plants are growing wild in areas extending from Missouri to California and south into Mexico. They could be cultivated at very little expense, and their seed harvested mechanically, on land which is now agriculturally unproductive or fit for very inadequate cattle range.

RAPID METHOD FOR DETERMINING FAT CONTENT OF DRIED EGGS. C. Paley and S. Rubin (Certified Labs., Inc., N. Y.). *Food Industries 18*, 1194-5 (1946). By a modification of the Babcock test, using the "Paley" bottle with special strength acids, the fat content of egg powders can be determined with reasonable accuracy, and in less time than is required by the A.O.A.C. method.

THE RANCIMETER PREDICTOR OF KEEPING QUALITY. F. E. James. *Food in Canada 5*, 15 (1945). A new "Rancimeter" process involving titration tests shows a definite change in materials as they reach various stages. The results interpreted into months reveal how long a product will remain saleable on the grocers' shelves. By this method it has been possible to isolate and identify minute quantities of ingredients in a formula causing accelerated rancidity. Information is obtained in half a day which formerly required 4 months of storage tests. (*Biol. Abs. 20*, 772.)

CATALYTIC DEHYDROGENATION OF FATTY ACIDS. E. Raymond and J. Moretti. *Compt. rend. 222*, 893-5 (1946). The study of the dehydrogenation of the higher aliphatic acids was undertaken to determine