hydraulic cake, according to the mill superintendent's wish.

The difference between the material weighed in and the weight of the products accounted for is the invisible loss and amounts, for the twenty-four hour period of the test, to three hundred seventy-seven pounds, or 1.34 per cent of the meats run. Taking a figure of 1263 pounds of meats per ton of clean seed, derived from the seed analyses, gives a figure of 22.17 tons clean seed worked during the twenty-four hours. The invisible loss, calculated on this more common basis, amounts to 0.85 per cent.

Since the total amount of oil produced amounted to 7,060 pounds and analysis showed 860 pounds oil in the cake and 148 pounds oil in the filter press cake, the total oil thus accounted for amounted to 8,068 pounds, or a gain of 119 pounds over the indicated oil content of the original meats. This serves to show that experimental error, probably largely in sampling for analysis and weighing the many batches, introduced an experimental error that might well have made the over all figures show a gain rather than a loss.

It is believed that the data obtained would be considerably more accurate if the test could have been run over a much more extended period of time in order to minimize possible inequalities of start-up and stop times. Furthermore, the samples were, of necessity, taken on one day and run the next, and, while they were kept in tight cans, moisture changes must inevitably have crept in, especially in the cake samples, which were taken hot.

This test thus indicates that there is no more than a negligible amount of unaccounted for loss in Expeller operation on cottonseed.

THE PRESSURE COOKING OF COTTONSEED MEATS AND ITS APPLICATION TO THE EXPELLER

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Abstract

A discussion of the design of and results obtained from a new type of cotton seed cooker with special reference to its effect on the oil produced by the Expeller.

DURING the past several years a considerable amount of work has been done at the University of Tennessee Engineering Experiment Station at Knoxville on the pressure cooking of cottonseed meats. This work showed such great promise that, when the opportunity to install an Expeller in the experimental setup presented itself, it was gladly accepted.

The Expeller used in the work was what is known as an Anderson Half-Size Model DUO. This is a working model of the standard DUO machine, but with one-half the linear dimensions. It is small enough for easy workability and handling but large enough so that its results are directly transferable in practice to the larger machines. It was equipped with an agitated "hat box" feeder of sufficient size to hold batch lots as they were dumped in.

The setup at Knoxville consists of a complete small oil mill. The seed is shipped in delinted but not hulled, and is handled according to standard mill practices until it reaches the cooker. Here, instead of an ordinary stack cooker, the new pressure cooker, designed by Mr. F. W. Weigel and built by the T. V. A. for the Experiment Station, is used. The meats from this cooker are then pressed, either in a box press or in the Expeller.

It would probably be well to say a few words about the pressure cooker and the characteristics of the cooked meats it produces.

In appearance it resembles a large bucket built of steel plates, thirty-three inches in diameter by forty inches in length, internal dimensions, with a cover and resting in a horizontal position. There is a one-inch steam jacket completely surrounding its ends and circumference. Agitation is one of the most important and best worked out features of the cooker. It is supplied by a set of opposed helixes operating on a shaft turning at about 40 r.p.m. These helix blades are two inches in width and three-quarters of an inch thick. They are machined, as is the entire interior of the shell, to obtain the desired one-sixteenth-inch clearance between the blades and the shell. Each pair of helixes tends to throw the material to the center, longitudinally, of the cooker, where there is a one-inch space between the two sets for thermometers or other instruments. The knives in each set are 180° apart and one set is 90° in advance of the other.

Since the scrapers curve as helixes, they cut into the material at an angle of about 45°, not only pushing it, but sliding it, and are thus self-cleaning. Actually, the knives, side walls and thermometer are, at all times, cleaned and polished by the action, although, at one stage of the cooking, the material has the consistency of half-cooked oatmeal. Inasmuch as a two-inch layer of meats is wiped from the bottom and thrown into the upper parts of the cooker 76 to 80 times a minute, the effect is that the meats are, for all practical purposes, in suspension in the cooker. The meats are dumped in through a hole, at the top, sealed by a screw clamp lid on a flange. The meats are released after the cooking and pressure blow-off through a steam-piston actuated, hinged, trap, discharge door.

Besides the jacket steam inlet pipes, the cooker is so equipped as to permit controlled entry of steam to the batch itself. There is an adjustable bleeder valve to control interior pressure, set at present for fifteen pounds. Duration of blow off of pressure at the end of the cook is controlled by a needle valve.

The method of operation is as follows:

The charge of rolled meats, usually from 350 to 500 pounds, is dumped in while the agitator shaft is rotating and the steam jacket carrying from 125-150 pounds per square inch steam pressure. The door is then clamped shut. As the temperature of the meats rises, moisture is given off and a pressure is built up. The objective is a condition, determined to give best results by many trial and error experiments, of from 15 to 17 pounds internal pressure and 270° F. internal temperature. Thus the steam in the cooker is somewhat superheated when ultimate conditions are reached. If the meats cooked are unusually dry, the proper pressure can not be attained, so, in these circumstances, live steam is admitted directly to the cooking chamber to build the pressure up to the desired limits. If the meats are exceptionally high in moisture, too great a pressure results. This is corrected by the use of a bleeder valve with an adjustable blow-off point, which causes the pressure to be held to the desired fifteen pounds.

The meats are not held at the optimum temperature. As soon as the thermometer indicates the temperature has reached 270° F., the pressure is released and the meats then dropped from the cooker to the lower stage. In releasing the pressure, a bleeder valve is used, since the time elapse in pressure release determines the final moisture content of the meats as dropped to the lower stage. It has been found that the same moisture, between four and five per cent, is required both for the Expeller and the press and that this is obtained by a bleed off period of about one minute. A longer blow off period will cause dryer meats and, conversely, a shorter period, wetter meats.

Total time for the cook runs from 14 to 17 minutes, less than one-third the time consumed in ordinary cooking.

From both a chemical and physical aspect, the work of the pressure cooker is of considerable interest.

It produces a meats batch of distinctly different characteristics from that produced by an ordinary stack cooker. The batch is entirely uniform due to the excellent agitation and control features of the cooker. In form, the material produced is a light, fluffy mass, of color, varying according to the seed used, from the usual yellow-red of ordinary cooking to a brilliant red. Oil is easily squeezed from it in the hand. When formed into cakes, in the hydraulic cake former, it is somewhat rubbery and oil is easily caused to flow even under the light pressure applied in the device.

The present theory of pressure cooking is this:* The cotton seed oil cell is made up of a core, containing oil and protein particles surrounded by four "skins." The outer layer consists of hemi-cellulose; the second layer, of calcium pectate; the third, of hemi-cellulose again; and between the third layer and the "core," a membrane analogous to the inner membrane of an egg.

This inner membrane and the calcium pectate layer are water soluble and the intimate contact with moisture in the cooker dissolves them.

When the cooker is in operation, conditions of moisture, temperature, and pressure are well suited to hydrolysis reactions. Then, too, there is usually enough acid present in the seed as free fatty acid to act, to some extent, as a catalyzing agent. Thus the hemi-cellulose layers are thought to be hydrolyzed leaving a kind of "strainer" through which the oil filters in pressing. The protein in the cell coagulates and thus does not press out with the oil. This protein coagulation is one of the most important features of pressure cooking. Rolling the meat does not affect the oil cell structure as has been shown by photomicrographs. It appears only to expose them to the action of cooking, the tremendously increased surfaces for reaction probably being the most important contributing factor.

It is possible, but as yet unproved, that pressure cooking of meats will have the same detoxicating effect as autoclaving of meal. Experimental work to obtain information in this regard is being carried on at the University of Tennessee Agricultural Experiment Station at Knoxville and at Ohio Agricultural Experiment Station at Wooster.

In the cooking, a small amount of black or dark brown, highly adhesive, glue-like material forms and has a tendency to collect at blow off points. It seems to be made up of pentosans and may be isolated and further hydrolzed to a material in the furfural group. It is believed that this glue is the end product resulting from the hydrolysis of the hemicellulose. It must be taken into account in valve design.

In working with the cooker in connection with the Expeller, four questions were uppermost, namely, what condition should the feed be in; how should the machine be adjusted; what quality oil could be produced, and how low could the extraction be made. These questions were, of course, inter-related, a change in conditions in any phase usually affecting all others.

Experimentation was, of necessity, mostly of a trial and error nature. It was finally determined that best results were obtained by using the same feed as was employed for the box press. That is, the meats were rolled to 0.010″ or less and cooked to 270° F., 15 lbs. pressure, then exhausted for one minute yielding a feed containing 4 to 5 per cent moisture. This feed was raised to a temperature of 230° F. in the tempering apparatus of the Expeller and pressed, using a standard cottonseed setting in the machine. A most interesting aspect of the pressing was the fact that the temperature fell off in a steady curve as the material progressed through the barrels rather than rising to a maximum in the vertical barrel as is the case in usual practice. There were exceptionally few foots.

No matter how red the meats fed in, the meal was unusually bright and of good quality.

Far and away the most important aspect of the work was the oil produced. Extraction was good, but was not stressed, no particular effort being made to adjust the machine for maximum extraction. It was proved that oil remaining in cake could be held as low as 4.21 per cent on a 4 per cent moisture basis, giving a standard of 47, but it was thought best to leave work on extraction until a time when the machine could be operated twenty-four hours a day.

The oil produced in the Expeller was not Expeller oil as it is generally known. This was true only when rolled meats were used. On whole meats, the cooker acts only as a dryer and a typical crude, requiring the "Expeller" refining process, that is, requiring a greater quantity and a stronger concentration of caustic as well as longer agitation period in the refining test than the method known as "hydraulic refining," was produced in the machine.

The oil from rolled meats refined with a less quantity of, and a weaker, caustic and produced a firm hard soap stock. Apparently, pressure cooking so affects the structure of the meats that the Expeller produces a crude which does not refine as a typical Expeller oil. It seems to be an oil having some of the characteristics of both the Expeller and hydraulic oils. This fact has been attested to by the commercial laboratories cooperating in the experiment who have repeatedly refined the oil by all possible standard methods before deciding that best results could be obtained by using less caustic than usual Expeller practices require.

This pressure cooker is a definite and real development in cottonseed

(*It should be noted that, while the following explanation is the accepted one, it has not been proved. Work is being done along these lines at present.)

milling. Properly designed, it can be used unchanged for box press or Expeller operation. Improperly designed, it is little better than the ordinary hydraulic cooker. It obviates the necessity of a dryer in an Expeller setup.

Redesigned, if possible, as a continuous operation, it could be used with the Expeller as a one-piece milling unit ideally adapted to small, single-unit work.

As a batch, or as a continuous cooker, it gives results which will greatly improve the cottonseed mill process, box press and Expeller and certainly warrants more research and experimental work.

COMPOSITION OF A SOYBEAN OIL OF ABNORMALLY LOW IODINE NUMBER[1]

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Abstract

Oil from Dunfield soybeans (Columbia, Mo., 1936) having a very low iodine value, has been examined. Comparison of the constants of this abnormal oil with normal soybean oils indicates no significant differences except in iodine value and refractive index. Based on the calculated composition of the unsaturated acids, the abnormal oil appears to contain a higher percentage of oleic acid, and a lower percentage of linoleic and linolenic acids, than do normal oils. The lowered iodine value does not appear to be correlated with any increase in the stability of the hydrogenated product. The abnormality is attributed to an accumulation of unfavorable varietal, climatic, and pedological factors.

IN THE course of the investigation of the chemical composition of soybeans as affected by agronomic factors, there was encountered at the U. S. Regional Soybean Industrial Products Laboratory one lot of beans which yielded an oil of abnormally low iodine number. So far as the authors are aware, the iodine number of this oil, namely, 101.6, is the lowest ever recorded for an American cultivated variety of grain-type soybean.

The beans in question represent a Dunfield variety derived from Indiana seed and grown in test plots at Columbia, Missouri, during 1936. It is evident from the data[3] recorded in Table I that except for the iodine number of the extracted lipids, the beans appear to be similar in composition to those of the same variety and source grown at the same location during 1937. In view of this anomaly it was deemed of interest and value to determine, if possible, the chemical factors which were responsible for the abnormality in the iodine number of the oil derived from the 1936 crop.

In order to accomplish this purpose 22.2 kg. of the dried flaked beans were extracted with Skellysolve F, yielding 4.22 kg. of solvent-free oil, equivalent to 20.06 percent of the moisture-free beans. A portion of the oil was forwarded to the Procter and Gamble Company to which the authors are indebted for the information concerning its refining, bleaching and hardening properties, while the remainder was analyzed in this laboratory. For purposes of comparison 5.54 kg. of dried (2.87 percent moisture) flaked beans, representing the 1937 Missouri crop, were likewise extracted with Skellysolve F. The yield of oil in this case amounted to 1.19 kg., or 20.8 percent of the moisture-free beans. For further comparison a sample of oil extracted from Dunfield soybeans grown at Lafayette, Indiana, was similarly examined.

Results of the examination of the three soybean oils are presented in Table II. From these results it is seen that, except for the low iodine number and refractive index of the oil obtained from the 1936 crop from Columbia, Missouri, all the oils appear to be quite similar and altogether normal for Dunfield beans. It is also evident from the results recorded in Table III that the percentages of saturated and unsaturated acids for all three oils are quite normal, as is also true of the thiocyanogen numbers. Only the iodine number of the oil from the 1936 crop of beans indicates any abnormality.

TABLE I.—ANALYSIS OF DUNFIELD SOYBEANS GROWN AT COLUMBIA, MO.*

Analysis	1936 crop As received	1936 crop Moisture free	1937 crop As received	1937 crop Moisture free
Moisture, per cent	5.70	....	5.77	....
Nitrogen, per cent	6.42	6.81	6.02	6.39
Protein (N × 6.25), per cent	40.1	42.6	37.6	39.9
Ash, per cent	4.64	4.92	4.27	4.53
Potassium, per cent	1.68	1.78	1.58	1.68
Phosphorus, per cent	0.585	0.620	0.556	0.590
Calcium, per cent	0.276	0.293	0.196	0.208
Crude fiber, per cent	4.78	5.07	5.00	5.31
Polysaccharides as sucrose, per cent	6.12	6.49	7.32	7.77
Lipids (Skellysolve F), per cent	20.38	21.61	20.70	21.97
Iodine number of lipids	....	101.6	....	123.1

*Data supplied by the Analytical Section of this laboratory.

TABLE II.—ANALYSIS OF EXTRACTED OIL FROM DUNFIELD SOYBEANS

Analysis	Columbia, Missouri 1936	Columbia, Missouri 1937	Lafayette, Indiana 1937
Iodine number	102.9	124.0	127.3
Thiocyanogen number	78.0	79.6	80.2
Saponification number	191.1	193.2	192.1
Acid number	1.47	0.55	0.35
Diene number[4]	0.2	0.82	0.0
Hydroxyl number[5]	5.3	2.6	3.4
Unsaponifiable, per cent	0.84	0.70	0.66
Refining loss, per cent	3.2	....	....
Break, per cent	0.20	0.04	0.07
Phosphorus, per cent[6]	0.040	0.025	0.015
Color (1" cell)	70Y 4.2R	70Y 5.2R	70Y 3.5R
Refractive index, n^{25}/D	1.4700	1.4722	1.4723
Specific gravity $^{25}/_{25}$	0.9159	0.9179	0.9182

[4]See reference (1). [5]See reference (2). [6]See reference (3).

[1]Presented at the 29th annual meeting of the American Oil Chemists' Society, New Orleans, La., May 12-13, 1938.

[2]A cooperative organization participated in by the Bureaus of Chemistry and Soils and Plant Industry of the U. S. Department of Agriculture, and the Agricultural Experiment Stations of the North Central States of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

[3]Except where otherwise stated methods of analysis were those of the Association of Official Agricultural Chemists and the American Oil Chemists' Society.