The Effect of Processing Conditions on the Properties of Screw-Press Cottonseed Meal and Oil[1]

F. H. THURBER, H. L. E. VIX, WALTER A. PONS JR., A. J. CROVETTO, and N. B. KNOEPFLER,
Southern Regional Research Laboratory,[2] New Orleans, Louisiana

TO aid in obtaining the highest possible return from cottonseed products, attention is being directed not only to increasing the efficiency of processing but also to modifications in processing conditions to yield both meal and oil of highest quality (1, 5, 6, 7, 15, 16). Previously reported research (1, 9) indicated that screw-pressed meals prepared from low temperature dry-cooked meats (6) gave much higher growth rates, when fed to poultry and swine, than did those from high temperature wet-cooked meats. The former had a low free-gossypol content (the portion of the gossypol soluble in 70% acetone) and had suffered little protein damage. It is generally considered that for cottonseed meals to be suitable for unrestricted feeding to growing poultry and swine they must have the following two characteristics:

1. Low free-gossypol content (below 0.03%)
2. Minimum heat damage to protein

The free-gossypol content can be reduced during processing by destruction through chemical reaction, binding on the meal or extraction with the oil. In wet-cooking procedures nearly all of the pigment glands containing gossypol are broken during the cooking (3, 4) and most of the gossypol is bound to the meal, while in low temperature dry-cooking relatively few of the glands are broken in cooking and essentially all of those remaining are ruptured in the screw press (3). These conditions of low temperature dry-cooking result in meals with rather low total gossypol content (6), which may be one of the factors influencing their nutritive value. Several investigators have pointed out the influence of processing conditions on the gossypol-like pigments in cottonseed. Thus the amount of water added to the meats during cooking has a pronounced effect on the gossypol-like pigments in screw-pressed meal and oil (4) and is also related to the tendency toward bleach-color reversion in the crude oils upon storage (17). A survey of commercial cotton oil mills, while indicating considerable variability in the chemical properties of screw-press meals and oils (11), indicated that variations in cooking conditions can influence the distribution of the gossypol pigments between the meal and oil.

Many oil mill operators prefer moist high temperature cooking because of the somewhat greater press throughput, decreased fines, and improved oil quality. These conditions do not generally result in meals of optimum nutritive value. It should be possible to find a set of processing conditions acceptable to mill operators that will yield both meal and oil of highest quality.

The four mill scale studies reported in this paper were undertaken to produce quantities of low temperature dry-cooked meals to confirm the results obtained in previous studies (6) and to obtain information that may aid in developing processing conditions which will retain certain desirable features of both low temperature dry-cooking and high temperature moist-cooking.

Chemical properties of the meals and oils were determined at the Southern Regional Research Laboratory. Nutritional studies on the meals were made by cooperating nutritional laboratories and are being reported separately by these laboratories (8, 9).

Experimental

The experimental work for this investigation was conducted in two commercial cotton oil mills, both of which employed similar types of water-cooled screw-presses equipped with the vertical type of cookers mounted above each press. Four separate series of experiments were undertaken; these are designated as Series 5, 12, 14, and 15, respectively. Each series included several test runs, which consisted of selected variations in cooking and screw-pressing conditions. For each test a cooker-screw-press unit, operating under mill conditions, was gradually changed over to the experimental conditions. The collection of meals and oils was not started until the unit was operating satisfactorily under the experimental conditions for at least 1-2 hours.

The seed used in the four series were low in free fatty acid content (0.6-1.9%) but varied somewhat in moisture content. Seed used for Series 5 had 7% moisture; for Series 12, 6%; for Series 14, 9%; and 12% for Series 15.

At both mills the seed was delintered and hulled; the hull content was adjusted to yield final meals of approximately 41% protein. In Series 5, 12, and 14 (with the exception of test 3 in Series 14) the meats were cracked in a disc-type of huller prior to cooking. In Series 14, test 3, and for all tests in Series 15, meats were flaked to approximately 0.012 in. by use of conventional rolls.

The major processing differences were in the cooking procedures used. The variables investigated are grouped in three general classifications:

a) *Normal mill practice*—Series 12, test 1; Series 14, test 1, and Series 15, test 1. Prepared meats were cooked under the usual conditions employed at each mill, where moisture contents ranged from 6.6 to 11.4%, cooking temperatures from 239 to 254°F., and time from 30 to 75 minutes.

b) *Low temperature dry cooking*—Series 5, tests 5-17; Series 12, tests 2, 3, and 4; Series 14, test 2, and Series 15, test 2. Meats with moisture content of approximately 7% were cooked at temperatures from 160-200°F., to a final moisture content of 4-5%. Cooking time varied from 22 to 45 min. As no water was added in the cooker, the operation was essentially one of drying rather than cooking in the generally accepted terminology.

c) *Wet low temperature cooking followed by evaporative cooling*—Series 14, test 3; and Series 15, test 3. Meats adjusted to moisture contents of 12-18% were cooked at temperatures from 216-228°F. to a final moisture content of about 6%. Cooking times varied from 45 to 65 min. The cooked meats were cooled to 140°F. and fed to a conditioner, where the temperature was raised to 175°F. Air was drawn through the

[1] Presented at 44th Annual Meeting of the American Oil Chemists' Society, New Orleans, La., May 4-6, 1953.

[2] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Service, U. S. Department of Agriculture.

TABLE I.

Series 5. Processing Conditions and Chemical Properties of Meats and Press Cake

Run No.	Cooking conditions		Energy input to press	Chemical Properties					
				Moisture	Oil	Gossypol		Nitrogen	
	Maximum	Time				Free	Total	Solubility	Total
	°F.	*Minutes*	*amps.*	%	%	%	%	%	%
	Meats before cooking								
	....	....	....	6.80	28.4	0.647	0.688	55.8	4.73
	Press cake								
1	230	35	60	6.54	3.5	0.026	0.615	15.3	6.62
2	230	36	55	6.75	4.2	0.032	....	23.7	6.84
3	230	35	51	6.83	4.1	0.034	....	30.6	6.72
4	230	31	60	7.34	3.5	0.034	....	16.9	6.79
5	200	22	51	6.42	3.3	0.038	0.619	37.9	6.80
6	200	22-26	55	7.24	4.1	0.028	....	37.2	6.76
7	200	22-26	55-58	7.19	3.7	0.028	....	30.0	6.83
9	180	22-26	55	6.37	3.9	0.018	0.530	31.7	6.40
10	180	22-26	50	6.26	3.4	0.050	0.575	41.4	6.12
12	180	22-26	60	6.69	3.8	0.032	0.485	23.0	6.25
13	200	22-26	60	5.90	3.8	0.026	0.555	26.5	6.10
14	200	22-26	50	6.25	4.4	0.043	0.520	42.2	6.14
16	160	38	58	6.57	3.5	0.019	....	35.0	6.03
17	185	33	57	6.44	4.5	0.042	....	45.0	6.00

meats in the conditioner to reduce the moisture content to about 4-5%, total conditioning time being 10 min.

As far as possible, pressing conditions were selected to conform with accepted commercial practice with respect to throughput. While in some cases the throughput had to be reduced, in all cases press performance was adequate.

Samples and Methods of Analysis

Samples of the products at each stage of processing were taken at intervals throughout the duration of the test runs, composited, and mixed before analysis. Meats, cooked meats, and meals were analyzed for moisture, oil, and total nitrogen by use of the American Oil Chemists' Society official methods (2), and for free gossypol (12), total gossypol (13), and nitrogen solubility in 0.5 molar sodium chloride (10) by published procedures. Crude oils were analyzed for free fatty acids, refining loss, and refined color and bleach color by application of official methods (2) and for total gossypol (14).

Results and Discussion

Earlier investigations (6) had indicated that variations in cooking temperatures and in energy input to the press (amperage applied to press motor at constant voltage) resulted in the production of meals having marked differences in chemical and nutritional properties. Accordingly the 14 meals in Series 5 were prepared in order to verify the results previously obtained. No attempt was made to collect or evaluate oil samples. Processing information and analytical data are given in Table I. Normal operating conditions were used in producing meals 1 and 4. The energy input to the press was lowered in obtaining meals 2 and 3. Both cooking time and energy input were lowered in obtaining meals 5 through 17, inclusive. While all the meals were low in free gossypol content (Table I), considerable variations are noted in nitrogen solubility. For meats cooked at 230°F., reduction of energy input to the press from 60 to about 51 amperes resulted in an increase in nitrogen solubility from 15 to 31%. By lowering cooking temperatures to 200°F. and below and varying cooking time and energy input, meals ranging from 23 to 45% in nitrogen solubility were obtained. Results from chick feeding studies with these meals (9) indicated that variations in either cooking or pressing of cottonseed meats may have a profound effect on the nutritive value of the meal. The most important variable seemed to be the maximum temperature of cooking, the best meals being those cooked at 200°F. or below.

Having demonstrated that superior screw-pressed cottonseed meals could be produced by low temperature dry cooking, three series of experiments (Series

TABLE II

Effect of Cooking Conditions on Chemical Properties of Cooked Meats

Series and test no.	Meats preparation	Description of cooking conditions	Cooking Conditions				Chemical Properties of Cooked Meats			
			Moisture content meats in cooker		Maximum cooking temp.	Total cooking time	Free gossypol		Nitrogen solubility	
			Initial	Final			Amount	Percentage reduction	Amount	Percentage reduction
			%	%	°F.	*minutes*	%	%[a]	%	%[b]
12–T1	Cracked	Normal mill conditions	6.6	2.7	243	30	0.53	27.9	59.0	20.3
12–T2	Cracked	Dry, low-temperature	7.0	4.5	162	30	0.67	10.8	63.0	14.9
12–T3	Cracked	Dry, low-temperature	6.6	4.7	179	30	0.66	12.9	65.0	12.2
12–T4	Cracked	Dry, low-temperature	7.0	4.1	200	30	0.63	19.8	65.0	12.2
14–T1	Cracked	Normal mill conditions	6.9	3.1	239	45	0.52	32.8	40.1	22.4
14–T2	Cracked	Dry, low-temperature	7.7	4.0	198	45	0.58	15.8	53.3	18.5
14–T3	Flaked[c]	Wet, low-temperature[d]	12.0	6.0	228	65	0.07	91.0	37.6	41.0
15–T1	Flaked[e]	Normal mill conditions	11.4	2.9	254	75	0.16	81.8	25.6	59.4
15–T2	Flaked[e]	Dry, low-temperature	9.9	4.9	197	45	0.53	46.1	47.4	22.4
15–T3	Flaked[e]	Wet, low-temperature[d]	18.2	6.6	216	45	0.09	89.7	37.8	28.7

[a] Percentage of free gossypol in prepared meats which was bound in cooking.
[b] Calculated from nitrogen solubility of meats before and after cooking.
[c] 0.008-0.010".
[d] Evaporative cooling.
[e] 0.012".

TABLE III
Effect of Processing Conditions on Chemical Properties of Press Cake

Series and test no.	Pressing Conditions					Chemical Properties—Press Cake						
	Temp. meats to press	Energy input [a]	Temp. press cake	Thickness press cake	Yield press cake	Moisture	Oil	Nitrogen solubility	Gossypol		Reduction in pressing	
									Free	Total	Gossypol [b]	Nitrogen solubility [c]
	°F.	amps.	°F.	inches	#/5 min.	%	%	%	%	%	%	%
12–T1	241	55.2	248	0.20	61.5	2.90	3.90	23.3	0.028	0.80	45.7	48.2
12–T2	160	50.5	196	0.17	62.5	6.60	5.21	53.1	0.054	0.63	40.2	13.4
12–T3	180	49.5	204	0.19	62.5	6.82	5.03	53.6	0.035	0.62	37.2	15.4
12–T4	200	52.0	220	0.22	64.0	6.04	4.40	40.7	0.028	0.65	38.0	32.8
14–T1	240	53.9	252	0.17	61.0	2.73	3.80	16.1	0.043	0.87	41.8	46.4
14–T2	200	51.4	221	0.08	50.0	4.32	3.73	21.7	0.029	0.84	41.2	59.5
14–T3	175	50.0	195	0.08	51.0	4.60	4.23	18.6	0.030	0.95	0.0	22.6
15–T1	254	103.0	252	0.23	55.0	3.07	4.72	10.5	0.046	1.11	6.5	24.0
15–T2	195	113.0	218	0.16	50.0	4.21	3.80	16.5	0.031	0.94	28.6	50.6
15–T3	176	115.0	200	0.19	50.0	5.55	5.23	18.4	0.043	1.10	3.7	36.6

[a] Series 12 and 14, at 440 V. Series 15 at 220 V.
[b] Percentage of the free gossypol in the original meats bound in the press.
[c] Percentage decrease in nitrogen solubility during pressing, referred to nitrogen solubility of the orignal meats.

12, 14, and 15) were undertaken to determine the effect of modified processing procedures on the quality of both meal and oil.

The influence of the selected variations in preparing, cooking, and screw-pressing the meats on the properties of meal and oil in Series 12, 14, and 15 is shown by the data summarized in Tables II through V. Consideration of these individual operations serves to emphasize the importance of the variables studied.

Meats Preparation. Use of a "disc-huller" for cracking meats in Series 12 and Series 14, T-1 and T-2, resulted in the binding of 9-18% of the gossypol in the meats (Table V). The amount bound varied directly with the closeness of the settings. The use of rolls for flaking the meats in Series 14, T-3 (0.008-0.010 in.) caused some 21% of the gossypol to be bound while flaking for Series 15 (0.012-0.014 in.) bound little if any gossypol.

Cooking. Variations in moisture content, temperature, and time during cooking have a pronounced effect on the chemical properties of the cooked meats (Table II). Cooking dry, cracked meats (7% moisture) at temperatures in the range of 160-240°F. resulted in very little gossypol binding (12.2-18.5%). While low, the level of gossypol binding in Series 12 and Series 14, T-1 and T-2, varies directly with the cooking temperature. When flaked meats were cooked at moisture levels of over 12%, considerable gossypol reduction took place. In particular, wet low temperature cooking followed by evaporative cooling (Series 14, T-3, and Series 15, T-3) resulted in the binding of approximately 90% of the gossypol. This level compares favorably with those attained in the cooking operations for hydraulic pressing (11) That high temperatures are not required for gossypol reduction in cooking is shown by the results for Series 15, T-1 and T-3. Cooking for 45 min. at 216°F. and at 18% moisture-bound approximately 90% of the free gossypol (Series 15, T-3) while cooking at 254°F. at 12% moisture for 75 minutes resulted in 82% of the gossypol being bound (Series 15, T-1).

Lacking specific analytical methods, the percentage of the total nitrogen soluble in 0.5 molar sodium chloride was used as an approximate measure of the damage to the protein during processing. Cooking reduces the amount of soluble nitrogen in the protein, and, in general, the reduction is much less in dry cooking at a given temperature than in wet cooking. Increases in temperature also reduce the amount of soluble nitrogen, and the effect is more pronounced at high moisture levels.

Pressing. The effect of pressing conditions on the properties of the press cake and crude oil are shown in Tables III and IV. Normal mill operations (Series 12, T-1, Series 14, T-1, and Series 15, T-1) yielded meals with low free gossypol content but at the expense of considerable protein damage. The temperature of the meats entering the press is apparently related to the loss in soluble nitrogen during pressing. Thus in Series 12 minimum loss (13.4-15.4%) occurred when meats entered the press at 160-180°F., somewhat more (32.8%) at 200 °F., and the largest amount (48.2%) at 241°F. In Series 14, T-2, and Series 15, T-2, where it was necessary to reduce both cake thickness and throughput to achieve low free gossypol in the cake, the loss in soluble nitrogen was high (51-60%). It would seem that as far as loss in soluble nitrogen is concerned, the screw-pressing is the critical operation as the loss generally exceeded that during cooking.

Low free gossypol contents were obtained in all of the press cakes. Considerable binding of gossypol occurred during passage of the meats through the press when the free gossypol content of the meats entering the press was about 0.5%. When this level dropped to 0.07-0.16%, very little binding occurred in the press, indicating that the rate of reaction was considerably reduced.

The gossypol content of the crude oils varied considerably (Table IV), ranging from 0.12% to 1.14%. These differences are a direct result of the cooking procedures employed and are emphasized by the gossypol distribution tabulated in Table V.

Gossypol Distribution. The experimental processing conditions resulted in a striking difference in the distribution of the gossypol between the products, meal, and oil (Table V). A rather constant proportion (2.4-5%) of the original gossypol appeared in the meal as free gossypol. The data show that the total gossypol content of the press cake and the gossypol concentration in the crude oil is largely governed by the amount of gossypol bound in cooking. For dry low-temperature cooking very little binding occurred during cooking, as a result of which a considerable proportion of the gossypol was expressed in the crude oil (23-38%) and the press cakes were lowest in total gossypol content (Table III). Normal mill practice resulted in a slightly higher level of binding during

TABLE IV

Analysis of Crude Oils Before and After Storage at Elevated Temperatures

Series and test no.	Original Crude Oils					Crude Oils Stored 40 Days at 95-100°F.			
	F.F.A.	Gossypol content	Refining loss	Lovibond color		Gossypol content	Refining loss	Lovibond color	
				Refined	Bleached			Refined	Bleached
	%	%	%			%	%		
12–T1	1.0	0.395	6.5	5.7	2.5	0.254	4.8	10.2	5.2
12–T2	1.8	1.07	5.6	5.4	2.3	0.790	5.5	22.9	12.0
12–T3	1.8	1.14	5.6	6.2	1.9	0.835	5.4	23.8	11.7
12–T4	1.8	0.975	5.6	6.0	2.6	0.692	5.5	32.8	14.7
14–T1	1.7	0.478	7.3	6.6	2.7	0.290	6.7	16.7	7.9
14–T2	2.0	0.756	6.2	7.4	2.7	0.606	6.6	14.6	9.2
14–T3	1.3	0.132	5.9	5.3	2.3	0.086	6.0	8.3	3.2
15–T1	1.4	0.273	7.6	6.6	1.7	0.235	7.5	10.2	4.5
15–T2	1.9	0.793	7.5	6.4	1.7	0.653	8.9	23.5	8.6
15–T3	1.9	0.116	8.0	6.6	1.7	0.090	8.0	8.8	2.6

cooking (24-82%), with a resultant meal higher in total gossypol and oil lower in gossypol content. Wet low-temperature cooking, where most of the gossypol was bound during cooking (70-90%), gave meals highest in total gossypol content (Table III) and crude oils containing very little gossypol. While the screw-press can bind a considerable portion of the gossypol, in no case was more than 54% of the free gossypol present in cooked meats bound during passage through the press (Table III). This suggests the critical effect of the cooking conditions, selection of which allows wide variations in the distribution of the gossypol between meal and oil.

Oil Quality. The properties of the crude oils, listed in Table IV, indicate that both dry low-temperature and wet low-temperature cooking produced oils which were initially equal or superior to those obtained from the normal mill practice. The outstanding difference in the oils was the amount of gossypol-like pigments, which varied from 0.12 to 1.1%. Upon storage for 40 days at 95-100°F., considerable color reversion occurred in many of the oils. Experiments conducted at 37°F. and 70°F. indicated that the rate of color reversion was reduced materially at these temperatures. The extent of this color reversion is apparently directly related to the gossypol content of the oil before storage. While gossypol content decreases on storage (Table IV), the color reversion is not related to the percentage decrease in gossypol. Both refined and bleach color increase on storage. However it is the increase in bleach color which is more directly related to the gossypol content. This increase in

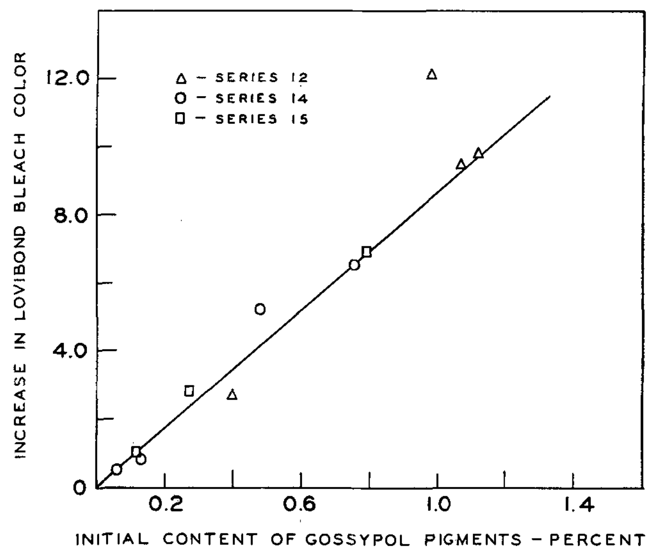

FIG. 1. Increase in Lovibond bleach color vs. content of gossypol pigments in crude oils stored 40 days at 95-100°F.

bleach color on storage of crude screw-pressed oils at elevated temperatures has previously been noted (17, 18) although no direct relation was found between processing variables and the amounts of gossypol found in the crude oils, or between the amount of gossypol in screw-pressed oils and their bleach color before and after storage (18). These investigators (17, 18) attempted to estimate the amount of unchanged or native gossypol in the meals and oils. It

TABLE V

Distribution of Gossypol in Processing

Description	Series and test no.	Meats, preparation	Cooking—Conditioning				Distribution of Gossypol Contained in Raw Meats During Processing[a]				
			Maximum temp.	Time total	Moisture of meats		Bound in meats preparation	Bound in cooking	Bound in press	Removed in crude oil	Left in meal as free gossypol
					Initial	Final					
			°F.	min.	%	%	%	%	%	%	%
Normal screw-press	12–T1	Cracked meats	240	30	6.6	2.7	14.0	24.0	45.7	14.0	2.4
Normal screw-press	14–T1	Cracked meats	240	45	6.9	3.1	8.7	29.9	41.8	15.8	3.6
Normal screw-press	15–T1	Flaked meats (.012″)	250	75	11.4	2.9	0.0	81.8	6.5	7.9	3.3
Dry, low-temp. screw-press	12–T4	Cracked meats	200	30	7.0	4.1	10.1	17.8	38.0	31.8	2.4
Dry, low-temp. screw-press	14–T2	Cracked meats	200	45	7.7	4.0	17.6	14.5	41.2	24.4	2.4
Dry, low-temp. screw-press	15–T2	Flaked meats (.012″)	200	45	9.9	4.9	0.0	46.1	28.6	23.3	2.2
Dry, low-temp. screw-press	12–T3	Cracked meats	180	30	7.0	4.5	10.1	11.6	37.2	38.0	3.1
Dry, low-temp. screw-press	12–T2	Cracked meats	160	30	7.0	4.5	9.0	9.8	40.2	36.1	5.0
Wet, low-temp., cooked, cooled screw-press	14–T3	Flaked meats (.008″-.010″)	228	80	12.0	3.8	21.2	71.7	0.0	4.4	3.0
Wet, low-temp., cooked, cooled screw-press	15–T3	Flaked meats (.012″)	216	60	18.2	4.9	0.0	89.7	3.7	3.4	3.2

[a] Moisture and oil free basis.

seems that the closely related gossypol-like pigments present in crude screw-pressed oils and included in the values determined for total gossypol (14) in the present investigation are responsible for the increase in bleach color of the crude oils on storage. This relationship is illustrated by the data shown in Figure 1, where the initial content of total gossypol pigments in the crude oils is plotted against the increase in bleach color after storage of the crude oils for 40 days at 95-100°F.

Summary

Processing conditions, particularly cooking procedures, have a marked influence on the chemical properties of screw-pressed meal and oil. Cooking prepared meats at 240-250°F., as in normal mill practice, produced meals with low free gossypol content but at the expense of considerable protein damage. The resultant crude oils showed some color reversion upon storage at 95°F. Dry cooking (7% moisture) at temperatures not exceeding 200°F. gave meals of improved chemical properties, but the crude oils exhibited considerable color reversion on storage.

Wet low-temperature cooking (200-210°F.), followed by evaporative cooling, yielded a meal intermediate in quality between that for normal mill practice and dry low-temperature cooking. The crude oils, which corresponded to hydraulic-pressed oil, did not exhibit any appreciable color reversion upon storage at elevated temperatures.

The selection of processing conditions, notably cooking, enables wide variations in the distribution of gossypol between meal and oil.

The increase in the bleach color of crude oils stored at 95-100°F. was found to be directly related to the initial gossypol content of the crude oils.

Acknowledgments

The mill scale tests were made possible by the interest and cooperation of the South Texas Cotton Oil Company, Harlingen, Tex., and the Central Oil and Milling Company, Clayton, N. C.

The authors are indebted to Vidabelle O. Cirino, Alva F. Cucullu, and Julian F. Jurgens for many of the chemical analyses reported in this paper.

The assistance of Aaron M. Altschul, E. A. Gastrock, T. H. Hopper, and P. A. Williams in the planing of this investigation is gratefully acknowledged.

REFERENCES

1. Altschul, A. M., Official Proc. 55th Ann. Convention, Natl. Cottonseed Products Asso., *1951*, 32-34, 36.
2. *American Oil Chemists' Society*, "Official and Tentative Methods of Analysis," Ed. 2, rev. to 1951, Chicago, 1946-1951.
3. Batson, D. M., Thurber, F. H., and Altschul, A. M., J. Am. Oil Chemists' Soc., *28*, 468-72 (1951).
4. Boatner, C. H., Hall, C. M., O'Connor, R. T., Castillon, L. E., and Curet, M. C., J. Am. Oil Chemists' Soc., *24*, 97-106 (1947).
5. Dechary, J. M., and Altschul, A. M., Oil Mill Gazetteer, *54*, No. 2, 13-15 (1949).
6. Haddon, R. P., Schwartz, A. K., Williams, P. A., Thurber, F. H., Karon, M. L., Dechary, J., Guice, W., Kupperman, R., O'Connor, R. T., and Altschul, A. M., Cotton Gin and Oil Mill Press, *52 (i.e., 51)*, No. 9, 18-20 (1950).
7. Knoepfler, N. B., Vix, H. L. E., and Thurber, F. H., Cotton Gin and Oil Press, *53*, No. 6, 16, 18, 61-66 (1952).
8. Lyman, C. M., Chang, W. Y., and Couch, J. R., J. Nutrition, *49*, 679-90 (1953).
9. Milligan, J. L., and Bird, H. R., Poultry Science, *30*, 651-657 (1951).
10. Olcott, H. S., and Fontaine, T. D., Ind. Eng. Chem., *34*, 714-16 (1942).
11. Pons, W. A. Jr., Murray, M. D., LeBlanc, M. F. H. Jr., and Castillon, L. E., J. Am. Oil Chemists' Soc., *30*, 128-132 (1953).
12. Pons, W. A. Jr., and Guthrie, J. D., J. Am. Oil Chemists' Soc., *26*, 671-676 (1949).
13. Pons, W. A. Jr., Hoffpauir, C. L., and O'Connor, R. T., J. Am. Oil Chemists' Soc., *27*, 390-393 (1950).
14. Pons, W. A. Jr., Hoffpauir, C. L., and O'Connor, R. T., J. Am. Oil Chemists' Soc., *28*, 8-12 (1951).
15. Wamble, A. C., Oil Mill Gazetteer, *53*, No. 3, 31-34 (1948).
16. Wamble, A. C., Oil Mill Gazetteer, *54*, No. 1, 85-87 (1949).
17. Williams, P. A., Boatner, C. H., Hall, C. M., O'Connor, R. T., and Castillon, L. E., J. Am. Oil Chemists' Soc., *24*, 362-69 (1947).

[Received January 11, 1954]

Aqueous Vapor Pressure of Soybean Meal and Its Fractions[1]

P. A. BELTER, C. R. LANCASTER,[2] and A. K. SMITH, Northern Utilization Research Branch,[3] Peoria, Illinois

THE role of water in the maturing and storage of soybeans and its effects on the changes in the proteins, carbohydrates, and other constituents of the bean have never been adequately evaluated. These water-colloid relationships are of primary importance in understanding processing operations involving desolventizing, toasting, and dehydration of soybean products as well as changes that occur during storage of the beans or meal.

Beckel, Bull, and Hopper (1) have published data showing the progressive denaturation of protein in soybean meal by the application of increasing amounts of moisture and heat. The moisture conditions imposed on the meals were defined in terms of the relative humidity maintained in the system during heating and as such cannot be directly translated into moisture content. Data have been reported on the hygroscopicity of soybeans and soybean oil meals by Ramstad and Geddes (11) and by Larmour, Sallans, and Craig (6). However in each case the information was obtained by equilibrating the samples in a series of desiccators, each containing a solution of constant humidity, maintaining the temperature at 25°C., and subsequently determining moisture contents. Such information is adequate for low temperature investigations. However processing conditions are seldom at this temperature level, and in the present investigations it was deemed necessary to include temperature as a variable. It is interesting to note that because of the empirical nature of the results obtained by existing procedures for determining moisture of biological materials, it has been advocated by Makower and Myers (8) that aqueous vapor pressure replace the moisture determination as an indication of the extent of hydration.

The present investigation was undertaken to establish the moisture adsorbing capacity of soybean oil meal and its fractions at various temperatures by a manometric method. Such data will be applicable to many practical soybean production problems as well as to the storage of these materials.

[1] Presented at fall meeting of American Oil Chemists' Society, November 2-4, 1953, in Chicago, Ill.
[2] Formerly with the Northern Utilization Research Branch.
[3] One of the branches of the Agricultural Research Service, U. S. Department of Agriculture.