However even in the presence of a large concentration of radicals, such as pyrolysis would produce, the chain could propagate further.

In summary, it would appear that the polymerization of β-tung oil might be considered as the limiting case in thermal polymerization. With non-conjugated oils this basic reaction seems to be accompanied by other reactions: some necessary, such as conjugation; and others, purely satellite. The basic reaction has many of the characteristics of a Diels-Alder reaction, and Clingman's recent proof of the presence of six-membered rings in the reaction products (5) is additional supporting evidence for this hypothesis. Of the alternative reactions, only those involving radicals are likely to occur in the absence of deliberate catalysis and then only at relatively high temperatures. The high activation energy of the reaction involving non-conjugated acyl groups might be considered to be the sum of the energy of conjugation and the energy of polymerization. However no rate equation describing these conditions has yet been developed.

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Prepress-Solvent Extraction of Cottonseed, Processing Conditions and Characteristics of Products[1]

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THE use of screw-pressing prior to solvent-extraction is a growing development in the cottonseed processing industry. This process, commonly termed prepress-solvent extraction, comprised some 12% of the crush in 1951-1952 (6) and probably 20-25% at the present time. Since this indicates widespread availability of prepress-solvent extracted cottonseed meals and oils, the quality of these relatively new products is of considerable interest in current research on improving the value of cottonseed products (1, 2, 3, 9, 10). Accordingly a survey of this process was undertaken with the cooperation of 11 mills located throughout the cottonseed processing area. The survey was designed to yield information concerning the influence of processing conditions normally used by the cooperating mills both on the chemical properties of meals and oils and on the nutritive value of the meals.

Samples and Methods of Analysis

Samples, representative of the materials at various stages of processing, were obtained by appropriately compositing individual samples taken at regular intervals during a period of eight hours of normal operation by each mill. Where possible three complete sets of samples, taken at intervals of about six weeks, were obtained for each mill. Data on processing conditions are summarized in Tables I and II.

Moisture, oil, total nitrogen, free fatty acids, and free gossypol were determined by use of Official Methods of the American Oil Chemists' Society (4). Methods proposed by Pons *et al.* (14, 15) were employed for the determination of total gossypol in meats and meals and in crude oils. Nitrogen solubility was determined by dispersion in 0.5 M sodium chloride as proposed by Olcott and Fontaine (13), and in 0.02 N sodium hydroxide as suggested by Lyman *et al.* (11).

The crude oils were refined in accordance with Official Method Ca 9a-52 of the American Oil Chemists' Society; prepressed oils were treated as directed for expeller oils and solvent-extracted oil as indicated for hydraulic oils. These procedures were employed since no official refining methods are available for prepressed oils and for solvent-extracted oils from prepressed cake. The refined oils were bleached as directed by Official Method Cc 8a-52, and oil color was determined by use of the photometric method Cc 13c-50 of the American Oil Chemists' Society (4). The values reported for refining loss and oil color were selected in accordance with the settlement rules of the National Cottonseed Products Association (12).

Discussion of Results

It is generally recognized that, during the processing of cottonseed, the pigment glands which are dis-

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TABLE I

Processing Conditions, Meats Preparation and Cooking

Mill	Meats preparation			Cooking conditions				
	Type of rolls	Flake thickness	Moisture content, flaked meats	Moisture content of meats in cooker		Temperature of meats in cooker		Total cooking time
				Initial	Final	Minimum	Maximum	
		Inches	%	%	%	° F.	° F.	*Min.*
1	5-high	0.013	8.1	11.9	11.2	155	224	60
2	5-high	0.020	6.2	12.1	7.0	177	229	45
3	3-high	0.030	8.5	11.3	7.2	195	240	30
4	3-high	0.030	8.5	11.1	9.7	180	210	24
5	5-high	0.022	8.9	12.3	12.3	175	190	30
6	2-high	0.038	9.7	13.3	9.5	170	233	25
7	5-high	0.016	12.5	12.7	7.0	206	224	60
8	5-high	0.014	6.8	10.8	10.3	188	220	45
9	5-high	0.010	6.8	10.2	6.5	217	227	30
10	5-high	0.034	6.8	8.6	9.2	160	190	25
11	3-high	0.028	7.3	10.7	4.7	197	233	25

TABLE II

Processing Conditions, Pressing and Solvent-Extraction

Mill	Pressing					Solvent-Extraction					
	Moisture content		Press capacity	Cake thickness	Temperature of press cake	Material to extractor		Solvent extraction temperature	Maximum temperature in evaporator	Maximum temperature in stripper	Maximum temperature in meal dryer
	Meats to press	Press cake				Type	Moisture content				
	%	%	*lbs./hr.*	*In.*	° F.		%	° F.	° F.	° F.	° F.
1	9.0 [a]	9.7	....	0.46	199	Flake [b]	10.8	125	155	225	240
2	7.0	6.4	2900	0.38	194	Gran. [c]	5.8	154	175	221	....
3	7.2	7.5	4200	0.19	240	Gran. [c]	7.5	130	225	205	225
4	7.2 [a]	8.9	4200	0.50	230	Flake [b]	12.5	130	210	205	230
5	8.7 [a]	10.7	3500	0.30	212	Flake [b]	10.2	120	158	200	220
6	7.1 [a]	8.8	2127	0.13	200	Flake [b]	10.7	....	164	242	209
7	7.0	7.7	2820	....	....	Flake [b]	8.9	134	230	238	....
8	8.7 [a]	9.5	4100	0.38	208	Gran. [c]	9.8	122	205	205	230
9	6.5	7.3	2830	0.19	....	Gran. [c]	6.6	150	159	222	188
10	7.5 [a]	7.6	3200	0.44	227	Flake [b]	10.1	125	200	208	225
11	4.7	5.9	4150	0.15	217	Gran. [c]	5.9	130	190	230	212

[a] Cooked meats conditioned before pressing.
[b] Press cake ground and reformed into flakes prior to extraction.
[c] Press cake pulverized prior to extraction.

tributed throughout the kernel must be ruptured in order to allow the gossypol pigments to be bound to the meal components. This serves the two-fold purpose of reducing the free gossypol content of the meal and preventing excessive pigmentation in the crude oil. To realize the maximum value of the meal, the reduction of free gossypol should be accomplished with a minimum damage to the protein. Work reported by previous investigators (8, 16, 18, 20, 21) has emphasized that varying the conditions employed during processing influences all three quality factors, the free gossypol content of the meal, the pigmentation of the oil, and the protein value of the meal.

The findings of the present investigation are presented to illustrate the changes which occur in certain chemical characteristics of the meats and crude oils during processing. Both processing data and chemical properties have been averaged for each mill since examination of the data showed little variation for a given mill. Such averages reflect the over-all influence of processing conditions on the quality of meals and oils.

Oil Recovery. The data on the reduction of oil content during processing and the recovery of total oil are recorded in Table IV. The oil content of the prepressed cake was of course higher than normal screw-pressed cake. Less work was done on the meats in prepressing as compared to normal screw-pressing. The through-put ranged from 2,127 to 4,200 lbs. per hr. (Table II) which is far greater than 650 to 750 lbs. per hr. reported for normal screw-pressing (18). A high average oil recovery, 98%, was attained by the

TABLE III

Oil Contents and Recovery of Oil

Mill	Oil content (as received basis)			Removal of oil during processing		
	Prepared meats	Press cake	Solvent extracted cake	In pressing	In solvent extraction	Total
	%	%	%	%	%	%
1	25.8	9.7	0.51	69.5	29.0	98.5
2	31.4	9.2	1.05	78.6	19.2	97.8
3	29.6	11.3	1.62	70.8	25.3	96.1
4	29.6	11.1	0.47	69.6	29.3	98.9
5	26.2	9.7	0.52	70.1	28.5	98.6
6	29.8	12.0	0.70	67.8	30.6	98.4
7	26.2	12.4	1.07	62.1	35.1	97.2
8	32.1	10.1	0.86	76.0	22.2	98.2
9	27.2	10.7	0.27	68.7	30.5	99.2
10	29.8	8.8	0.47	77.1	20.9	98.0
11	26.6	11.5	0.65	65.5	32.8	98.3
Mean	28.6	10.6	0.74	70.6	27.4	98.0

TABLE IV

Free Gossypol Contents of Materials During Processing

Mill	Free gossypol (moisture and oil-free basis)				Gossypol content, crude oils	
	Prepared meats	Cooked meats	Prepress cake	Solvent extracted cake	Pressed oil	Solvent extracted oil
	%	%	%	%	%	%
1	0.96	0.075	0.058	0.038	0.050	0.032
2	1.42	0.20	0.064	0.057	0.20	0.11
3	1.24	0.30	0.112	0.068	0.38	0.23
4	1.24	0.48	0.107	0.039	0.60	0.20
5	0.94	0.20	0.051	0.033	0.33	0.11
6	1.01	0.29	0.072	0.034	0.25	0.086
7	1.01	0.21	0.101	0.046	0.19	0.18
8	1.51	0.38	0.096	0.056	0.55	0.23
9	1.05	0.34	0.092	0.063	0.33	0.22
10	1.01	0.49	0.056	0.028	0.66	0.098
11	1.04	0.42	0.110	0.063	0.40	0.20

mills; 70.6% was recovered in pressing and 27.4% by solvent extraction.

Gossypol Reduction. Changes which the gossypol pigments undergo during processing are indicated in Tables IV, V, and VI. In general, very little free gossypol reduction occurred during preparation of the meats for cooking. With the exception of Mill No. 7, all mills rolled meats with moisture contents in the range of 6.2 to 9.7% to flake thicknesses varying from 0.010 to 0.038 in. (Table I). Under these conditions only 0 to 8.9% of the gossypol contained in the meats was bound. These conditions were by no means optimum, as work reported by Reuther *et al.* (17) demonstrates that thorough rolling of meats containing 11-14% moisture to flake thicknesses of 0.005 in. can result in considerable free gossypol reduction. In accord with these observations, it is noted that the highest reduction, 22.8%, was attained by Mill No. 7 which rolled meats containing 12.5% moisture.

TABLE V

Total Gossypol Content of Meats, Cake, and Meal

Mill	Total gossypol, (moisture- and oil-free basis)		
	Prepared meats	Pre-press cake	Solvent extracted meal
	%	%	%
1	1.05	1.03	1.00
2	1.46	1.11	1.09
3	1.22	1.03	0.99
4	1.22	0.94	0.92
5	1.00	0.83	0.82
6	1.08	0.94	0.92
7	1.29	1.17	1.10
8	1.65	1.35	1.25
9	1.13	0.95	0.89
10	1.06	0.76	0.73
11	1.05	0.80	0.75

TABLE VI

Binding and Distribution of Gossypol

Mill	Distribution of gossypol contained in the original prepared meats						
	Bound in meats preparation	Bound in cooking	Bound in pressing	Bound in solvent extraction	In meal as free gossypol	Removed in pressed oil	Removed in solvent extracted oil
	%	%	%	%	%	%	%
1	8.6	83.8	0.0	0.0	3.2	2.8	0.3
2	2.9	84.5	0.1	0.0	4.2	5.3	0.8
3	0.0	76.2	4.5	0.5	5.1	10.8	2.1
4	0.0	61.3	9.2	3.9	3.3	17.0	2.4
5	6.9	72.6	4.5	0.7	3.5	9.3	1.4
6	7.0	67.4	8.3	1.4	3.2	7.9	1.1
7	22.8	61.6	2.1	0.1	3.7	4.2	2.1
8	8.9	67.7	2.4	0.0	3.5	13.6	1.6
9	6.7	65.0	8.6	0.0	5.8	9.1	2.4
10	6.4	48.8	13.3	0.2	2.7	23.6	0.9
11	1.7	58.9	12.2	1.8	6.4	11.4	2.6
Mean	6.5	68.0	5.9	0.8	4.1	10.5	1.6

Cooking conditions were responsible for the major reduction in the free gossypol, the average for all mills being 68% (Table VI). Moisture content, temperature, and duration of cooking were all significant variables which influenced free gossypol reduction. It is note-worthy that 30-min. cooking at a constant moisture level of 12% and at relatively low temperature (190°F.) was quite effective in lowering free gossypol content (Mill No. 5). When meats containing less moisture were progressively dried during cooking to below 7% moisture (Mills Nos. 9 and 11), less gossypol was bound even though higher temperatures were employed. The least reduction occurred when meats containing about 9% moisture were cooked at 190°F. for 25 min. (Mill No. 10). Cooking for longer periods of time (45-60 min.) at higher temperatures (224-229°F.) resulted in still greater reductions in free gossypol (Mills Nos. 1, 2, and 7). Although some mills conditioned the meats after cooking, mainly to reduce the moisture content, little if any gossypol reduction was achieved during this operation.

Reduction in free gossypol occurred during prepressing (Table IV) due in part to reaction with the meats to form "bound" gossypol and in part to removal by solution in the pressed oil. The amount removed in the pressed oil, 10.5%, was greater than that bound to the meal, 5.9% (Table IV). As a consequence of the milder pressing conditions, far less gossypol was bound to the meats in prepressing than has previously been reported for normal screw-pressing conditions (16, 18). As a result the gossypol contents of some of the pressed oils were higher than those reported (16) for normal screw-pressed oils. The amounts of gossypol in the pressed oil were largely governed by the amount of free gossypol remaining in the meats after cooking (Table VI).

Free gossypol content of the cake was also lowered during solvent extraction (Table IV), but in most cases this was accomplished by solution in the solvent-extracted oil. The gossypol distribution data in Table VI show that very little gossypol was bound during solvent extraction. It is probably significant that the six mills which produced meals of the lowest free gossypol content all ground and reflaked the press cake prior to solvent extraction (Table II). It is possible that the process of grinding and reflaking press cake served to rupture some of the intact pigment glands remaining after cooking and pressing, allowing the gossypol to be dissolved in the solvent-extracted oil. Moisture added during grinding and reflaking could also have been a contributing factor. It is noted (Table IV) that the gossypol contents of the solvent-extracted oils in several cases were as high at 0.20-0.23%. This is due to the fact that the solvent-extracted oil represented only an average of 27.4% of the total oil in the original meats (Table IV), and the seemingly small proportions of gossypol removed in solvent extraction (Table IV) were contained in a smaller amount of oil.

Nitrogen Solubility. Changes in the solubility characteristics of the protein during processing as measured by nitrogen solubility in 0.5 M sodium chloride and in 0.02 N sodium hydroxide are given in Tables VII and VIII. From these data the reductions in nitrogen solubility during processing were calculated.

Several investigators (8, 13, 16, 18) have used nitrogen solubility in 0.5 M sodium chloride as a measure of the denaturation which cottonseed protein undergoes during processing. The greatest reduction in nitrogen solubility in 0.5 M sodium chloride occurred during cooking (Table VII), considerably less reduction occurring during prepressing and solvent- extraction. The reductions during cooking ranged from 13.0 to 34.4% and tended to correlate with both maximum temperature and time of cooking. Mills which cooked at the lowest temperatures (Mills Nos. 5 and 10) produced minimum reductions while those which cooked at higher temperatures (Mills Nos. 3, 4, 9, and 11) or for longer periods of time (Mills Nos. 1, 2, and 7) attained somewhat greater reductions in nitrogen solubility in 0.5 M sodium chloride. The reductions occurring during prepressing, ranging from 3.0 to

TABLE VII

Nitrogen Solubility in 0.5 Molar Sodium Chloride

Mill	Nitrogen solubility 0.5 M NaCl				Reduction in nitrogen solubility in 0.5 M NaCl			
	Prepared meats	Cooked meats	Press cake	Solvent extracted cake	During cooking	During pressing	During solvent extraction	Over-all
	%	%	%	%	%	%	%	%
1	74.4	48.8	39.2	37.0	34.4	12.9	3.0	50.3
2	64.3	43.1	35.6	36.2	32.9	11.8	0.0	44.7
3	64.2	46.7	....	42.7	27.3	....	....	33.5
4	64.2	50.3	44.5	43.1	21.7	9.0	2.2	32.9
5	60.4	52.7	49.1	47.2	13.0	5.7	3.5	22.2
6	71.3	49.3	45.7	40.8	30.9	5.7	6.9	43.5
7	64.5	43.5	41.6	38.0	32.5	3.0	5.5	41.0
8	61.3	44.6	40.3	38.0	27.2	7.1	4.6	38.9
9	66.7	48.4	42.0	43.1	27.5	7.0	0.6	35.3
10	69.1	55.7	50.5	47.5	19.2	7.6	4.4	31.2
11	57.5	40.3	36.5	32.6	29.8	7.7	6.3	43.3
Mean	65.3	47.6	42.5	40.6	26.9	7.8	3.7	37.8

12.9%, were far less than those which have been reported for normal high temperature screw pressing (13), where reductions of as high as 59% were found to occur.

Nitrogen solubility in 0.02 N sodium hydroxide has been proposed by Lyman and associates (11) as a chemical measure which is superior to solubility in 0.5 M sodium chloride for estimating the protein value of cottonseed meal. Recent studies (9) on the influence of heating on the nutritive value of cottonseed meal tend to support this suggestion. These investigators (9) demonstrated that heating cottonseed meal produced a gradual reduction in nitrogen solubility in 0.02 N sodium hydroxide and, further, that the reductions in nitrogen solubility are related to changes in the nutritive value of the meal.

Data for nitrogen solubility in 0.02 N sodium hydroxide (Table VIII) indicate that cooking was responsible for the major reduction in nitrogen solubility. In general, greater reductions were observed for mills cooking at higher temperatures or for longer periods of time. These reductions however, did not parallel those found for solubility in 0.5 M sodium chloride (Table VII) as cooking conditions which caused considerable reductions in sodium chloride solubility (Mills Nos. 6, 9, and 11) did not produce comparably high reductions in sodium hydroxide solubility. In agreement with the salt solubility data, low temperature cooking (Mills Nos. 5 and 10) resulted in minimum reduction in nitrogen solubility in 0.02 N sodium hydroxide. The data would seem to indicate that, of the various cooking procedures used, those employed by Mills Nos. 5, 6, 9, 10 and 11 caused minimum reductions in nitrogen solubility, and presumably minimum protein damage.

Since less oil was removed from the meats in prepressing as contrasted to normal screw-pressing, less work was done on the meats and they were subjected to lower temperatures and pressures. These conditions apparently caused very little protein damage as judged by the small average reduction of 1.3% in the nitrogen solubility in 0.02 N sodium hydroxide (Table VIII). The conditions employed during solvent-extraction and meal drying caused a further reduction in nitrogen solubility ranging from 0.9 to 8.7% (Table VIII). The average reduction during solvent extraction, 5.7%, was somewhat higher than that found during prepressing.

Oil Quality. Laboratory refining data for the prepressed and solvent-extracted oils are tabulated in Tables IX and X, respectively.

Prepressed oils (Table IX) generally refined to a prime color and were bleachable. After storage of the crude oil for 30 days at 100°F. all of the oils had higher bleach colors. This phenomenon, which has been termed bleach color reversion, has been reported to occur in certain screw-pressed oils (18, 20, 21). The extent of color reversion in these screw-pressed oils has been found to be related to the gossypol content of the crude oils (18). From the data given in Table IX it is apparent, for the prepressed oils, that the bleach color reversion was not strictly proportional to the gossypol content of the crude oil.

The solvent-extracted oils (Table X), without exception, were higher in both refined and bleached color than were the prepressed oils. The initial bleach color of the solvent-extracted oils did not seem to be

TABLE VIII

Nitrogen Solubility in 0.02 Normal Sodium Hydroxide

Mill	Nitrogen solubility 0.02 N NaOH				Reduction in nitrogen solubility in 0.02 N NaOH			
	Prepared meats	Cooked meats	Press cake	Solvent-extracted cake	During cooking	During pressing	During solvent extraction	Over-all
	%	%	%	%	%	%	%	%
1	94.5	73.4	71.6	68.2	22.3	1.9	3.6	27.8
2	94.2	70.2	67.2	66.4	25.4	3.2	0.9	29.5
3	99.0	73.7	......	66.7	25.6	....	....	32.6
4	99.0	73.1	73.5	65.0	26.2	0.0	8.6	34.8
5	93.1	76.1	79.5	74.6	18.3	0.0	5.4	23.7
6	95.4	76.2	75.9	71.6	20.0	1.7	4.5	26.2
7	87.1	71.0	71.6	64.8	24.2	1.0	7.8	26.9
8	90.0	70.2	68.9	65.3	21.9	1.4	4.1	27.4
9	93.7	80.8	74.9	73.6	13.8	3.0	4.7	21.5
10	94.6	80.3	81.0	72.7	15.1	0.3	8.7	24.1
11	90.3	73.6	72.9	66.4	18.5	0.8	8.2	27.5
Mean	93.7	74.4	73.7	68.7	21.0	1.3	5.7	28.0

TABLE IX
Refining Data, Prepressed Oils

Mill	Original prepressed oils					Prepressed oils stored 30 days at 100°F.			
	Free fatty acids	Total gossypol	Refining loss	Oil color [a]		Total gossypol	Refining loss	Oil color [a]	
				Refined	Bleached			Refined	Bleached
	%	%	%			%	%		
1	3.3	0.050	12.6	9.8	2.3	0.046	12.9	8.7	2.8
2	1.0	0.20	8.4	6.8	2.2	0.15	8.2	7.4	3.0
3	1.5	0.38	10.3	6.9	2.5	0.30	10.1	7.3	3.2
4	1.9	0.60	9.8	7.1	2.8	0.50	9.7	9.2	4.0
5	2.1	0.33	9.3	6.2	1.4	0.27	10.2	12.7	3.4
6	0.7	0.25	4.6	4.4	0.8	0.23	4.3	7.9	1.3
7	0.8	0.19	5.4	4.7	1.2	0.14	5.1	5.7	1.7
8	1.4	0.55	8.1	5.2	1.5	0.45	7.6	8.9	3.9
9	1.0	0.33	6.4	5.2	1.6	0.27	7.0	7.6	2.8
10	2.2	0.66	8.0	5.1	1.5	0.55	8.6	8.0	3.7
11	1.6	0.40	8.8	8.5	4.4	0.34	9.5	10.4	5.3

[a] Spectrophotometric color.

related to the cooking procedures employed at the mills although the oils from Mills 5 and 10, which employed low temperature cooking, compare favorably with those from other mills. It can be noted from the data in Table II that the temperatures employed in solvent evaporation and stripping were generally above 150°F. Previous information on the heating of cottonseed oil miscellas (5, 19) indicates that color fixation occurs within the temperature range of 150 to 180°F. and increases rapidly above 180°F. Such color fixation occurs in oil extracted from both cooked and uncooked cottonseed meats (5) and very probably involves the gossypol pigments present in the oil. On storage of the crude solvent-extracted oils at elevated temperatures (Table X), the bleach color increased. The average increase was 1.8 units. This was somewhat higher than the average increase for the prepressed oils, 1.0 units. Thus while containing considerably less gossypol the solvent-extracted oils had a slightly greater tendency toward bleach color reversion.

In the present investigation the prepressed and solvent-extracted oils were refined separately whereas in practice these oils are usually combined and refined as prepress-solvent oil. It should be emphasized that the data presented here are indicative of the quality of the two types of oils but not necessarily of the reconstituted oils.

Meal Quality. Summary data for the chemical properties of the 26 prepress-solvent extracted meals are given in Table XI. All of these meals have been submitted to nutritional laboratories for evaluation.

Free gossypol content, which ranged from 0.024 to 0.063%, was fairly constant for meals from a given mill. Five mills produced meals with free gossypol in the range of 0.025 to 0.040% while meals from the other six mills ranged from 0.040 to 0.063%.

Total gossypol content varied from 0.66 to 1.28% as a result of variations in the gossypol content of the meats (Table V) and of processing conditions which altered its distribution between meal and oil (Table VI).

Nitrogen solubility in 0.5 M sodium chloride (Table XI), which ranged from 25.5 to 47.8%, was considerably higher than the values which have been reported for normal high temperature screw-pressed meals, 8.5 to 20.1% (16). This would indicate that as far as protein denaturation is concerned, conditions employed in prepress-solvent extraction are somewhat milder than those for normal screw pressing.

Values for nitrogen solubility in 0.02 N sodium hydroxide ranged from 65.4 to 83.4% with many of the values being in excess of 70. The chemical indexes of protein quality suggested by Lyman and associates (11) which involves nitrogen solubility in 0.02 N sodium hydroxide divided by the total gossypol content are also reported in the table. These indexes ranged from 53.7 to 98.1 and in many instances compared favorably with those previously reported by Lyman and others (11) for meals of excellent protein value.

Summary

A study has been made of the relation between processing conditions and the chemical characteristics of cottonseed meals and oils produced by prepressing-solvent extraction. Twenty-six complete sets of mill samples of known processing history and representative of the production at 11 mills were used in the investigation.

Cooking conditions were the major factor influencing the distribution of the gossypol between the meal and oil. Reduction in free gossypol during cooking was due to binding with meal components while that occurring during prepressing and solvent extraction

TABLE X
Refining Data—Solvent Extracted Oils

Mill	Original solvent extracted oils					Solvent extracted oils stored 30 days at 100°F.			
	Free fatty acids	Total gossypol	Refining loss	Oil color [a]		Total gossypol	Refining loss	Oil color [a]	
				Refined	Bleached			Refined	Bleached
	%	%	%			%	%		
1	5.2	0.032	16.2	16.7	6.2	0.039	19.5	19.2	6.6
2	1.3	0.11	8.6	10.2	4.4	0.095	12.2	12.1	5.5
3	1.7	0.23	9.3	8.5	3.3	0.19	9.3	8.7	4.2
4	1.9	0.20	10.3	16.0	9.6	0.17	9.9	18.9	11.7
5	2.7	0.11	11.6	8.9	3.2	0.11	12.9	13.0	4.8
6	0.8	0.086	5.0	5.7	1.3	0.073	5.8	5.8	1.7
7	0.9	0.18	7.2	10.3	6.0	0.15	7.3	13.2	7.6
8	1.4	0.23	7.8	12.5	6.6	0.20	9.3	16.7	10.2
9	1.1	0.22	8.2	10.9	4.6	0.19	8.0	17.2	9.2
10	2.2	0.098	9.6	7.1	2.7	0.075	10.4	9.6	3.9
11	1.8	0.20	9.9	9.0	4.6	0.17	10.1	11.5	6.3

[a] Spectrophotometric color.

TABLE XI
Summary of Properties of 26 Prepress-Solvent Extracted Meals from 11 Mills

Chemical Properties (as received basis)	Range	Average
	%	%
Oil content	0.14 – 2.34	0.91
Free gossypol	0.024– 0.063	0.044
Total gossypol	0.66 – 1.28	0.93
Total nitrogen	6.35 – 7.32	6.72
Nitrogen solubility–0.5 M NaCl	25.5 –47.8	38.0
Nitrogen solubility–0.02N NaOH	65.4 –83.4	72.2
Chemical index	53.7 –98.1	76.9

resulted mainly from removal of gossypol in the prepressed and solvent-extracted oils.

Nitrogen solubility data, which have been suggested as a measure of protein damage, indicated that the major change or reduction in nitrogen solubility occurred during cooking. Very little reduction was noted for prepressing or solvent extraction. The reduction in nitrogen solubility during prepressing is much smaller than that previously reported for normal screw-pressing operations.

Prepressed oils gave lower refining losses and lower refined and bleached color than did the solvent-extracted oils. Bleach color reversion, after storage of crude oils for 30 days at 100°F., was greater for solvent-extracted than for prepressed oils.

A number of meals exhibited the desirable characteristics of low free gossypol content and high nitrogen solubility. Values calculated for chemical indexes of protein quality, as suggested by Lyman and associates (11), indicate that many of the meals should have good protein quality.

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The Nutritional Value of Prepress-Solvent Cottonseed Meals

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THE purpose of this paper is to report the results of a coordinated study of the nutritional value of prepress-solvent cottonseed meals. The feeding trials were conducted in four separate laboratories. No attempt was made to standardize on a single type of test, and each investigator used a method of his choice. The report of each laboratory constitutes a section of this paper.

Meals produced in commercial mills under varied but carefully controlled conditions were used. They were manufactured during a study of prepress-solvent mill operation by Pons, Thurber, and Hoffpauir (1), and the effects of processing conditions on the physical and chemical characteristics of the samples have been described by these authors.

It is also the purpose of this paper to evaluate further the relationship of the chemical and physical characteristics of cottonseed meals to the nutritional value of the protein. The free gossypol content of all meals used in this investigation (0.024-0.063%) was much lower than the minimum level which will result in gossypol toxicity in chicks (2). The types of nutritional tests conducted by the different laboratories varied considerably, but all were designed to measure protein quality.

If it can be established that certain physical and chemical characteristics of cottonseed meal are closely related to the nutritional value of the product, then analyses of the meals for these characteristics become extremely useful guides in the production of superior