Oil Quality From Hydraulic Pressed Soybeans

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Summary

HYDRAULIC pressed soybean oil quality is affected a great deal by the moisture of the beans at the time of milling. At moistures above 12 to 13% the oil quality deteriorates sharply. A great improvement in the oil from wet or even moisture damaged soybeans can be made by drying the beans to below 12% before milling. Even badly deteriorated (sample grade) beans have been vastly improved.

Blending of wet and dry soybeans to an average moisture below 12% does not seem to yield as good quality oil as drying wet beans to a corresponding moisture.

Normal variations in other soybean characteristics determining bean grade have lesser effects on soybean oil quality. Some data on the effect of bean damage, splits, off-color varieties, and foreign material are included in this paper.

Hydraulic oil mills operating on soybeans will be able to make large improvements in oil quality by drying whole wet beans at the mill and by removing foreign material from the beans.

THE large increase in soybean production during the last two years combined with severe restrictions on the erection of additional crushing capacity has made it necessary to crush considerable quantities of soybeans in hydraulic press mills. Most of these mills are in the south and operate normally on cottonseed. It seems probable that many of the mills will continue to crush soybeans whenever possible in order to fill out the short operating season on cottonseed, particularly since there is increased soybean production in the south. The effect of bean characteristics on oil quality from hydraulic pressed soybeans is consequently of much more current interest than it was a few years ago when the great majority of all soybeans were processed on continuous presses.

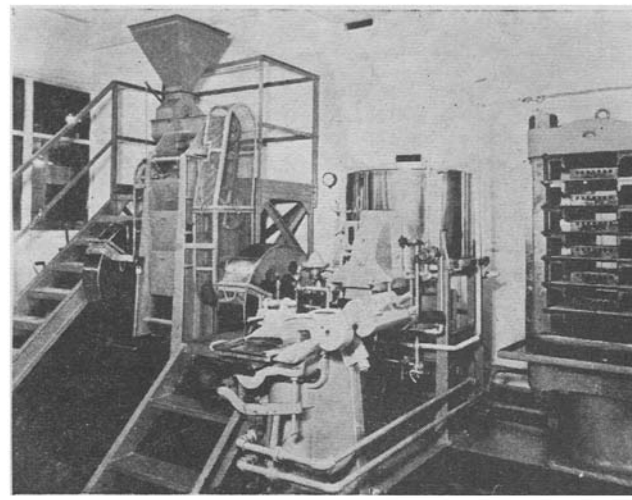
Soybeans are purchased by grade according to the:

1. Minimum test weight per bushel.
2. Per cent moisture.
3. Per cent splits.
4. Per cent damaged beans.
5. Per cent off-color beans.
6. Per cent foreign matter.

No work has been done on the effect of the test weight, but the other five variables have been examined to determine the effect on oil quality. This work was started in 1935; most of the tests were made on the 1936 bean crop with supplementary tests in the succeeding years.

Equipment

The present tests were made on pilot plant hydraulic equipment, consisting of an attrition mill for cracking, a 4-high stack roll, a batch cooker, 22″ in diameter and 18″ high, a former making a 6-lb. cake, and a 7-box press. Illustration No. 1 shows the roll, cooker, former, and press. A charge of 50 lbs. of soybean flakes was used. Three runs were made on each sample of beans, the first being used to flush out the equipment. An oil sample of 15-20 lbs. representing each sample was collected from the second and third runs. Most of the soybeans were from the Illinois and Iowa areas, but many varieties and many states are represented.



Pilot Plant Oil Milling Equipment.

Each charge was cracked, rolled, and introduced into the cooker at natural moisture, heated as rapidly as possible with jacket steam to 170-200° F., humidified with hot water to a moisture level of about 16%, and finished at 225-230° F. in 35 minutes.

Oil Quality Tests

The oil was first refined. The method used was slightly different from the present A.O.C.S. standards, because the latter had not been adopted at the time of the tests. The refined and filtered oil was then bleached with 3% of domestic earth; and the bleached oil was deodorized. The technique used in handling the oil after the crude was prepared has been described fully by Sanders (1), who has also defined the significance of the tests in determining oil quality.

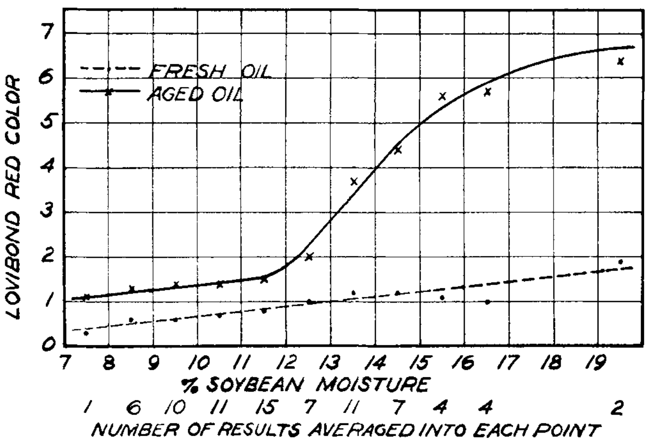
Four tests were used to determine actual oil quality or edibility:

1. Lovibond red color of the deodorized oil.
2. Flavor of the deodorized oil. The flavor rating was good, fair, or poor and is comparative only.
3. Lovibond red color on the aged, deodorized oil. A rapid aging at 140° F. for three days was used.
4. Flavor on the aged, deodorized oil.

Soybean moistures were determined by the Bidwell-Sterling (toluene distillation) method for most of the runs. For some of the supplementary runs a high frequency moisture meter calibrated against the Bidwell-Sterling value was used.

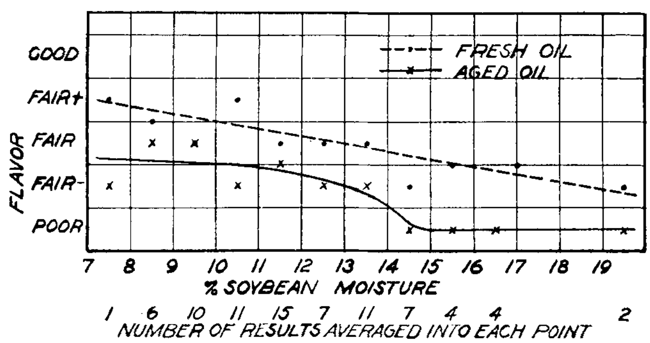
Effect of Soybean Moisture on Oil Quality

The results of the tests are shown in Graphs No. 1 and 2. It is seen that the oil quality obtained from soybeans from 8 to 12% moisture is good. Between 12 and 13%, the quality begins to deteriorate and becomes rapidly worse above 13%. The aged colors



GRAPH No. 1. Soybean moisture vs. color of deodorized oil.

and flavors are the best indices of quality in that original differences are magnified. Indeed, individual fresh flavors and colors are sometimes misleading as to the ultimate quality of individual samples of oil.



GRAPH No. 2. Soybean moisture vs. flavor of deodorized oil.

The graphs show the effect of bean moisture at the time of milling and include naturally wet beans that have been dried as well as naturally dry beans. Four of the individual results of drying beans, selected at random, are shown in Table 1. It is seen that all the samples fit the curves very closely. Consequently, it seems apparent that wet beans that have not been permanently damaged, i.e. that are processed soon after harvesting, can be dried to give practically as good oil as naturally dry beans. About two-thirds of the results averaged into the points below 12% were from originally wet beans, and the other third were naturally dry beans, at least as far as their history could be ascertained. Lovibond red color of the bleached oil, hereafter called RB Color, is included in the table for direct comparison with bean moisture in Graph No. 3.

A further test was made to check the effect of moisture alone by humidifying No. 1 grade Illinois

TABLE 1

Sample	Per cent moisture when milled	Deodorized Oil Quality				RB Color
		Flavor		Color		
		Fresh	Aged	Fresh	Aged	
1. (a) Undried	15	Fair	Fair—	1.1	6.0	6.2
(b) Dried	11.9	Fair	Fair	.5	1.1	2.5
2. (a) Undried	15	Fair	Poor	1.6	6.3	6.5
(b) Dried	10.3	Fair—	Fair	.4	1.0	2.1
3. (a) Undried	20	Fair	Poor	1.2	6.3	5.9
(b) Dried	11.6	Fair	Fair—	.5	1.1	2.2
4. (a) Undried	20	Fair—	Poor	2.5	6.6	6.9
(b) Dried	11.9	Fair—	Fair—	.5	1.9	1.6

seed beans from 10% to 12, 14, and 16% moisture. The following table shows the same deleterious effect although the quality was slightly better than the average of ordinary mill-run beans. This might have been suspected from the excellent quality of the beans.

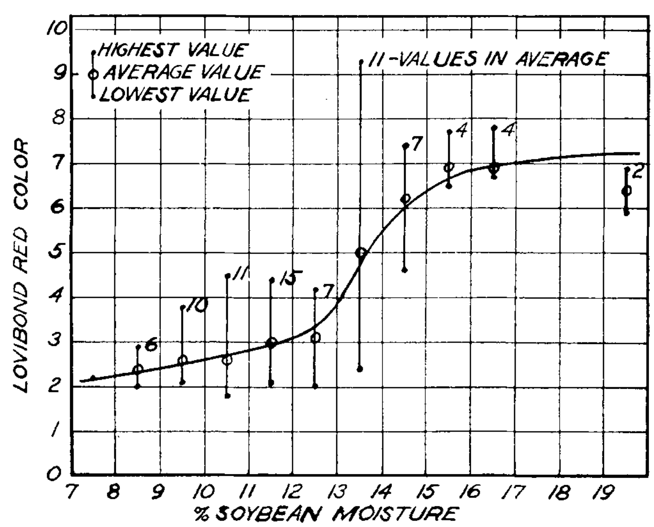
TABLE 2

Humidifying Dry Beans

"As Milled" Bean Moisture	Deodorized Oil Quality				RB Color
	Flavor		Color		
	Fresh	Aged	Fresh	Aged	
1. 9.8%	Fair+	Fair	0.6	1.1	2.2
2. 12.5%	Fair	Fair—	0.5	1.2	2.6
3. 14.2%	Fair	Poor	0.6	2.2	4.6
4. 16.4%	Fair	Poor	0.6	4.3	6.7

Effect of Blending Wet and Dry Beans

To test the effect of blending wet and dry beans, a wet and a dry sample were mixed in three ratios and compared to the original results on these samples. As shown in Table 3, the quality of the blends was definitely poorer than that from beans of corresponding moisture. For instance, the sample containing 50% of wet beans averages only 12.5% moisture and is within the good quality range; but the oil is as poor as from beans with a natural moisture of about 14%.



GRAPH No. 3. Soybean moisture of bleached oil color.

TABLE 3

Evaluation of Blending Wet and Dry Beans

Sample	Ave. H_2O	Deodorized Oil Quality				RB Color
		Flavor		Color		
		Fresh	Aged	Fresh	Aged	
a. Sample A Dry Beans	10.4	Fair	Fair	.5	1.2	3.1
b. 75% Sample A 25% Sample B	11.7	Fair—	Fair—	.8	1.6	3.5
c. 50% Sample A 50% Sample B	12.5	Poor	Poor	1.6	3.0	5.5
d. 25% Sample A 75% Sample B	14.0	Poor	Poor	2.1	5.4	8.1
e. Sample B Wet Beans	15.2	Fair—	Poor	1.8	5.5	8.0

Bleached Oil Color as an Index of Hydraulic Oil Quality

Sanders (1) showed that a quick test which is a good index of oil quality is the bleached Lovibond red color (RB Color). Graph No. 3 shows an excellent correlation between the soybean moisture and

TABLE 4

Effect of Splits

Condition	Soybeans		RB Color	Deodorized Oil			
				Flavor		Color	
	% H_2O	% Splits		Fresh	Aged	Fresh	Aged
A.							
1. Sample C.							
a. Held 2 wks. at 70° F.	15*	<10	6.2	Fair	Fair—	1.1	6.0
b. 100% split—Held 2 wks. at 70° F.	15*	100	6.8	Fair—	Poor	1.4	6.2
c. 100% split—Held 2 wks. at 120° F.	14* (dried out in storage)	100	6.5	Fair	Fair—	1.8	5.2
d. Same as 1 above but dried	11.9	100	3.6	Fair—	Fair—	1.4	2.2
2. Sample D.							
a. Held at 90° F. for two weeks	11.6	<10	2.2	Poor**	Fair—	0.5	1.1
b. 100% split—Held at 90° F. for two weeks	11.7	100	3.1	Fair—	Fair—	0.7	1.8
B.							
1. Whole beans	8.9	0	4.6	Fair	Fair—	0.8	1.3
2. Splits	9.1	100	5.6	Fair	Fair—	0.8	1.4

*Moisture meter result.
**Possibly a poor deodorization.

the RB Color. It is particularly interesting to see that the RB Color shows the same sudden increase in the moisture range from 12 to 14% that is exhibited by the aged color and flavor of the deodorized oil. Such an accelerated change is not shown by the fresh color and flavor, which merely decrease in quality fairly uniformly as the bean moisture increases. In other words, the RB Color, which can be obtained in less than 24 hours, seems likely to give an even better indication of the quality of the aged sample than that of the freshly prepared finished product.

Effect of Per Cent Splits

The effect of splits was checked by splitting two samples of beans in an attrition mill, holding the samples for two weeks, and milling the splits along with the original samples. The results are shown in Part A of Table 4. One sample dried out during this short storage and can be assumed to show better quality than would otherwise have been obtained. A third sample containing a high proportion of splits was separated by screening and the whole beans and splits were milled separately and compared to the original sample as shown in Part B. The results show a definite poorer quality from splits, but the magnitude is fairly small.

Effect of Damaged Soybeans

A numerical value for damage in a sample of soybeans is very difficult to obtain. Grading for damage depends entirely upon the personal judgment and experience of the grader and has none of the standardized mechanical aids that are used in the other grading factors.

The results of 15 samples obtained during a single season have been grouped according to moisture in Table 5. The bean grading was done by a single operator in accordance with government standards and instructions. The results show a slight positive correlation between bean damage and poorer oil quality, except for the samples containing 13 to 14% moisture. It is believed that borderline damage to samples, which is not included in the per cent damaged beans by government standards, is an important factor that obscures the true correlation. Even within the official definition of "damage" exists a wide variation in the actual deterioration.

TABLE 6

Effect of Off Color Beans

Sample	% H_2O	RB Color	Flavor		Color	
			Fresh	Aged	Fresh	Aged
1. 100% Illini	9.8	2.2	Fair+	Fair	0.6	1.1
2. 1% black	10.2	2.2	Fair+	Fair	0.6	1.4
3. 2% black	10.0	2.2	Fair+	Fair	0.6	1.1
4. 3% black	10.0	2.3	Fair	Fair	0.5	1.1

Effect of Off Color Beans

The effect of off color beans was checked by adding 1, 2, and 3% of black soybeans to No. 1 grade Illini

TABLE 5

Effect of Bean Damage

Sample	Soybeans		RB Color	Deodorized Oil			
				Flavor		Color	
	% H_2O	% Damage		Fresh	Aged	Fresh	Aged
1. Below 13% H_2O							
a. J.	12.5	1.3	2.0	Fair—	Fair—	0.4	1.2
b. I.	11.8	3.7	2.1	Fair+	Fair—	0.6	1.3
c. H.	11.6	7.5	2.4	Fair—	Fair	0.6	1.4
d. V.	11.9	over 50%	3.3	Fair—	Poor	0.5	1.9
2. Between 13 and 14% H_2O							
a. K.	13.2	2.0	9.3	Fair	Poor	2.8	9.2
b. L.	13.0	3.2	7.2	Fair—	Fair—	0.7	1.3
c. M.	13.8	3.4	6.7	Fair	Poor	0.4	4.1
d. N.	13.8	5.9	6.1	Fair—	Fair—	0.8	3.2
3. Between 14 and 15% H_2O							
a. O.	14.6	2.1	5.8	Fair	Poor	0.5	3.5
b. P.	14.9	4.9	5.6	Fair	Poor	1.2	4.0
c. Q.	14.8	6.5	6.6	Poor	Poor	0.9	5.9
d. R.	14.4	6.6	7.4	Fair	Fair—	0.8	6.3
e. S.	14.2	10.2	6.7	Fair	Poor	1.9	5.4
4. Over 15% H_2O							
a. T.	15.6	4.6	7.7	Fair—	Fair—	0.9	6.2
b. U.	16.2	9.0	6.9	Fair	Poor	1.1	6.0

TABLE 7

Effect of Foreign Material

Sample	% FM	% H_2O	RB Color	Deodorized Oil Flavor Fresh	Deodorized Oil Flavor Aged	Deodorized Oil Color Fresh	Deodorized Oil Color Aged
1. a. Illini	0.1	12.2	2.7	Fair+	Fair+	0.7	......
b. Illini	3 (added)	12.0	2.9	Fair+	Fair	0.9	......
c. Illini	6 (added)	11.5	3.7	Fair	Fair—	1.1	......
d. Illini	9 (added)	11.2	3.1	Fair—	Fair—	1.3	......
2. a. W—trashy, poor quality beans	15	12.2	12.9	Fair—	Poor	9.2	11.3
b. W—screened	0	12.7	9.3	Fair—	Fair—	3.3	6.3
3. a. X	11.3	10.0	4.3	Fair	Fair—	0.6	1.8
b. X—screened	0	10.4	3.2	Fair	Fair	0.5	1.2
4. a. Y	2.1	10.6	2.2	Fair	Fair	0.4	1.1
b. Y—screened	0	9.9	2.2	Fair	Fair	0.5	1.0

beans. The results in Table 6 show no significant variation.

Effect of Foreign Matter

A great difference can be expected to exist in the quality of the foreign matter in soybeans. The first test was made by separating the foreign matter from a quantity of soybeans by screening and adding 3, 6, and 9% to the Illini seed beans. The results in Table 7, Part 1, show a marked deterioration in quality with increased foreign material. A second series of tests was made by milling several samples that were high in foreign material and comparing the oil to that from the same beans after the foreign material had been removed by screening. The results show the same general trend of quality improvement by foreign material removal. Considerable quantitative variance in results should be expected in this type of test because of the non-uniformity of the material being removed.

Conclusions

The moisture of soybeans at the time of milling is a most important factor in obtaining good oil quality. It has been known that high moisture would cause soybeans to deteriorate in storage (2), (3), but the great effect of moisture at the time of milling whether on fresh or stored beans has not been published previously as far as is known.

The effect of splits and of damaged beans has not been established in any quantitative measure with the available data.

Foreign material is shown to be damaging to oil quality and a quantitative measure is shown by one test, but the unit effect of such material undoubtedly varies widely with its own characteristics.

In order to improve soybean oil quality, a hydraulic oil mill should dry all beans to the mill to below 12-13% and clean the beans of foreign material.

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Modification of Vegetable Oils

III. Fractional Crystallization of Fatty Acids From Solvents—Separation of the Solid and Liquid Acids of Cottonseed Oil

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VARIOUS investigators, including Brown and coworkers (4, 5, 6), Earle and Milner (8), and DeGray and DeMoise (7), have demonstrated the feasibility of separating saturated and unsaturated fatty acids by fractionally crystallizing mixtures of the acids from solvents at low temperatures. In published work in this field interest has centered on solvent crystallization as an analytical tool or as a method for the preparation of fatty acids of high purity. The object of the work reported here was to determine practicable conditions for carrying out the less exacting separations involved in the preparation of industrially useful products. Attention was given not only to the separation of cottonseed oil fatty acids into solid (saturated) and liquid (unsaturated) fractions, but also to the similar fractionation of the fatty acids of hydrogenated cottonseed oil. In the case of the hydrogenated acids, the solid acids include iso-oleic acids produced during the course of hydrogenation.

Experimental Procedure

The fatty acids used were obtained from two different lots of raw cottonseed oil and from a single batch of hydrogenated cottonseed oil. The latter was hydrogenated under conditions deliberately chosen to produce a rather high content of iso-oleic acid (3). Analyses of the fatty acids are listed in Table 1.

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