Soy-Bean Oil

Quality and Yield as Affected by Conditions of Expression

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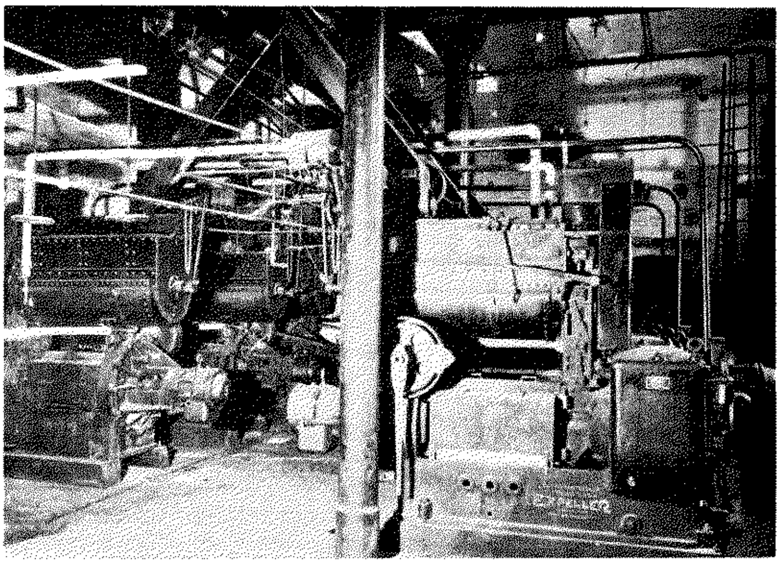
Apparently the first soy beans were introduced into the United States in 1804. At that time they were regarded as a botanical curiosity and it was not until recent years that the soy-bean industry developed extensively. According to Morse (*2*) the first soy beans milled in this country were pressed in a cottonseed-oil mill in North Carolina in 1913. The production of soy-bean oil and soy-bean oil meal has increased very much in the last five years. In 1917 the estimated yield for the United States was a million bushels, while in 1931 the yield was 14,917,000 bushels. Illinois is the leading state in soy-bean production, with North Carolina second and Indiana third.



Expellers Used in Producing Soy-Bean Oil and Meal by Expeller Process

Soy-bean oil is used commercially for a wide variety of purposes: in paints, varnishes, lacquers, linoleum, waterproof fabrics, core-binding oils, soaps, etc. Soy-bean oil is also finding considerable use today as an edible oil.

For many purposes, particularly in the manufacture of paints and varnishes, a "nonbreak" soy-bean oil is desired. A "nonbreak" soy-bean oil is one that when heated to a temperature of approximately 600° F. shows little or no precipitate and bleaches to a colorless or a very pale yellowish colored oil. The soy-bean oil that is produced today by passing the beans through expellers or hydraulic presses when heated to 600° F. develops a dark color and a dark colored precipitate. This oil is known as a "break" oil.

It has been known for some time that when the beans are pressed cold without heating, a nonbreak oil may be obtained. In commercial practice, however, the yield obtained is much lower if the beans are pressed without heating. At the present time in commercial practice the beans are heated at temperatures above 100° C. Since the quality of the soy-bean oil is impaired by pressing at high temperatures, it seemed worth while to study the effect of moisture content and temperature of pressing on the quality of soy-bean oil.

Methods

A quantity of soy beans was ground fine enough to pass through a 2-mm. sieve and dried in the vacuum oven at a temperature of 48° to 50° C. The various moisture contents were obtained by placing a weighed quantity of the meal in a desiccator and adding to the desiccator the required amount of water. The ground soy beans were then permitted to remain in the desiccator with occasional stirring until the moisture had become uniformly distributed throughout the sample.

The samples of soy beans of known moisture contents were pressed in the laboratory hydraulic press and the temperatures were controlled by means of hot plates above and below the cylindrical press. The temperature on the inside

Table I. Effect of Temperature of Pressing and Moisture Content of Soy Beans on Quality of Oil

	Dunfield Soy Beans				Manchu Soy Beans															
	0.0 per cent moisture				0.0 per cent moisture				4 per cent moisture				6 per cent moisture				6 per cent moisture			
	Color of Oil		Iodine No. Oil		Color of Oil		Iodine No Oil		Color of Oil		Iodine No. Oil		Color of Oil		Iodine No. Oil		Color of Oil		Iodine No. Oil	
Temp. Pressed ° C.	Before break test	After break test	Before break test	After break test	Before break test	After break test	Before break test	After break test	Before break test	After break test	Before break test	After break test	Before break test	After break test	Before break test	After break test	Before break test	After break test	Before break test	After break test
Room temp.	30	10	132.5	128.9	30	5	132.0	125.7	30	5	133.5	126.0	30	5	132.4	128.1	35	5	130.6	127.0
40	35	5	133.6	127.0	35	5	133.7	128.6	40	5	133.2	127.1	35	5	133.6	128.0	40	5	132.4	127.5
45	35	5	134.0	127.8	35	5	131.8	127.9	40	5	135.6	127.4	40	5	134.4	128.5	40	10	134.9	128.3
50	40	10	133.3	127.7	35	10	132.6	126.8	40	5	134.0	128.1	40	5	134.0	127.0	45	10	132.9	129.1
55	40	10	133.6	128.4	40	10	135.3	126.3	40	5	133.2	128.9	40	15	133.1	127.9	40	25	131.9	128.0
60	35	15	134.1	129.9	40	20	132.3	126.7	50	10	131.8	128.3	35	25	131.2	127.7	40	45	133.1	127.1
65	40	40	134.8	130.0	45	15	135.2	127.6	55	15	133.7	128.0	40	45	131.7	128.3	35	50	134.3	127.6
70	45	45	133.9	127.9	40	30	135.2	127.0	35	45	133.9	126.5	40	75	133.4	126.9	40	75	132.6	128.3
75	45	55	131.4	127.5	45	35	134.2	125.9	40	75	135.1	127.4	45	100	133.3	127.4	40	100	133.1	128.6
80	50	65	132.6	128.9	45	45	132.8	128.6	45	100	133.9	126.5	45	105	131.1	128.4	35	105	134.2	127.4
85	55	80	133.8	128.7	45	50	133.6	127.6	50	110	134.2	127.6	45	110	136.0	127.7	40	105	132.2	128.0
90	60	85	132.9	126.5	45	75	132.2	125.6	55	110	134.1	126.9	50	110	132.0	129.0	55	110	134.0	127.9
95	50	100	134.0	128.0	45	80	132.0	127.0	60	110	133.7	127.9	55	110	133.1	127.8	65	110	132.9	128.3
100	60	100	131.8	126.3	55	85	134.0	126.2	60	110	133.7	128.4	65	110	131.2	128.1	65	110	133.4	127.4

of the cylinder was taken before pressing by means of a thermometer inserted in the sample.

The actual time required for pressing the sample was 2 hours. For the first 30 minutes the pressure was kept at approximately 5000 pounds per square inch. The pressure was raised to 10,000 pounds per square inch for the second 30 minutes, to 15,000 pounds for the third 30 minutes, and to 20,000 pounds for the final half hour. The oil flowing from the press was collected and filtered into a test tube which was stoppered tightly and stored in the dark until analyzed.

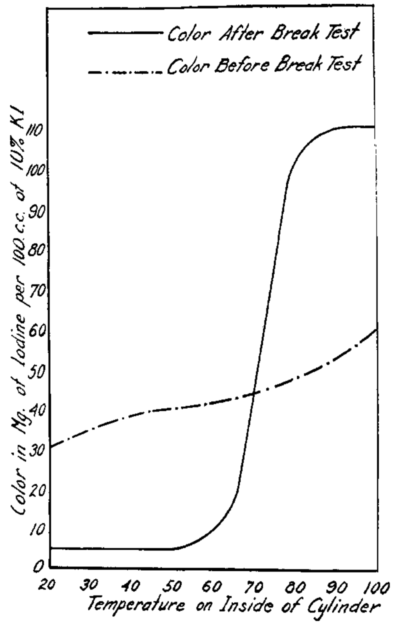


FIGURE 1. MANCHU SOY BEAN, 4.0 PER CENT MOISTURE. EFFECT OF TEMPERATURE OF PRESSING ON COLOR OF OIL BEFORE AND AFTER BREAK TEST

The color of each sample before and after the break test was compared with standardized iodine solutions according to Pallauf (3). The iodine value of the oil was determined by the Wijs method (1). The yield was determined indirectly by determining the oil content of the cake after pressing according to the method of the American Oil Chemists' Society (1). Two commercial varieties of soy beans, Dunfield and Manchu, were used in the studies.

RESULTS

Table I shows the color and iodine number of the oils before and after the break test when pressed under the different conditions. The figures given for color of the oils represent the number of milligrams of iodine in the iodine-potassium iodide solution which matched the color of the oil when equal depths of the two liquids were compared. Changes in moisture content and temperature of pressing of the soy beans did not affect the iodine number of the oil. Heating the oil during the break test lowered the iodine number of the oil in all instances.

When pressed dry, the results with the two varieties of soy beans were very similar. At temperatures of 55° C. or below, the color of the oil after the break test was similar to that pressed at room temperature after the break test, but when the temperature was raised above 55° C. there was an increase in the color of the oil after the break test. When the temperature of pressing reached 60° to 65° C., there was a rapid increase in the color of the oil after the break test.

With Manchu soy beans containing 4 per cent of moisture, a satisfactory nonbreak oil was produced by pressing at 65° C. With moisture contents of 6 and 8 per cent the color after the break test increased rapidly at 60° and 55° C., respectively.

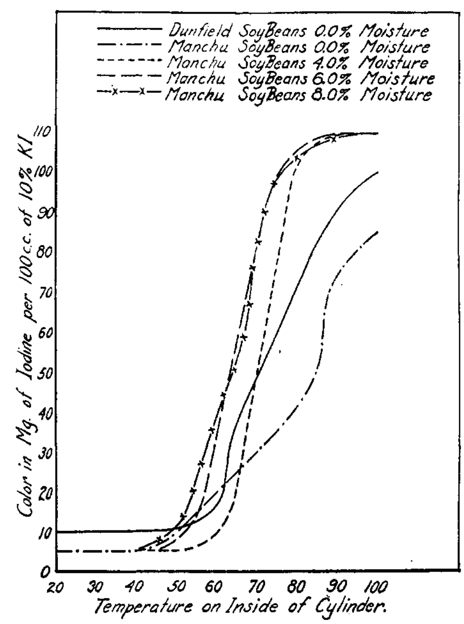


FIGURE 2. EFFECT OF TEMPERATURE AND MOISTURE ON COLOR OF OIL AFTER BREAK TEST

Figures 1 and 2 show the effects of pressing at different temperatures and moisture contents on the color of the oils before and after the break test. The color before the break

TABLE II. EFFECT OF TEMPERATURE OF PRESSING AND MOISTURE CONTENT OF SOY BEANS ON YIELD OF OIL AND PER CENT OF OIL IN CAKE[a]

	Dunfield Soy Beans 0.0 per cent moisture		Manchu Soy Beans 0.0 per cent moisture		Manchu Soy Beans 4.0 per cent moisture		Manchu Soy Beans 6.0 per cent moisture		Manchu Soy Beans 8.0 per cent moisture	
Temp. Pressed	Oil in cake	Oil extracted	Oil in cake	Oil extracted	Oil in cake	Oil extracted	Oil in cake	Oil extracted	Oil in cake	Oil extracted
° C.	%	%	%	%	%	%	%	%	%	%
Room temp.	11.7	39.3	12.9	33.3	11.4	38.7	10.7	41.3	10.0	44.1
40	8.4	56.5	11.4	41.1	8.3	55.4	9.9	45.7	10.6	40.8
45	9.5	50.7	9.8	49.3	7.3	60.7	8.0	56.1	7.4	58.7
50	8.2	57.5	7.3	62.3	7.9	57.4	8.8	52.0	9.6	46.4
55	7.7	60.1	9.5	50.9	6.9	62.9	9.0	50.7	9.7	45.8
60	8.9	53.9	6.1	68.5	7.2	61.3	10.6	41.9	9.4	47.5
65	6.5	66.3	8.4	56.6	6.9	62.9	8.3	54.5	8.9	50.3
70	5.8	69.9	5.6	71.0	5.6	69.9	6.2	66.0	7.6	57.5
75	7.5	61.1	7.0	63.8	6.4	65.6	6.0	67.1	6.0	66.5
80	4.6	76.2	6.3	67.4	8.3	55.4	6.3	65.5	5.1	71.5
85	3.5	81.9	5.8	70.0	7.7	58.6	5.9	67.7	7.5	58.1
90	5.2	73.0	5.2	73.1	8.2	55.9	5.7	68.8	6.7	62.6
95	4.1	78.7	4.4	77.2	6.2	66.6	6.1	66.6	6.3	64.8
100	4.1	78.7	5.3	72.6	5.1	72.6	5.9	67.7	5.6	68.7

[a] The fat contents of the dry soy beans were: Dunfield 19.29%, Manchu 19.34%.

test increased slightly as the temperature of pressing was raised. The color of the oils after the test was much lower than before, until the critical temperatures (50° to 65° C.) of pressing were reached and nonbreak oils were no longer produced. Above these critical temperatures the color of the oils after the break test increased very rapidly. It is interesting to note that these critical temperatures were raised as the moisture content of the beans was reduced. With beans of 4, 6, and 8 per cent of moisture the critical temperatures were approximately 65°, 55°, and 50° C., respectively.

Table II shows the effect of temperature of pressing and moisture content on the per cent of oil left in the cake. Better yields were obtained at the higher temperatures, although satisfactory yields were obtained at temperatures close to 65° C.

These results show that it is possible to obtain a satisfactory yield of a nonbreak oil by controlling the moisture content of the beans and the temperature of pressing. These results may not be entirely comparable with those obtainable in an oil mill where large hydraulic presses or oil expellers are used.

Summary

A nonbreak soy-bean oil is one that when heated to a temperature of 600° F. shows little or no precipitate and bleaches to a colorless or a very pale yellowish colored oil. The soy-bean oil produced by the expeller or hydraulic press when heated to 600° F. develops a dark color and a dark-colored precipitate and is a break oil. For many commercial purposes a nonbreak oil is desired. A study of the effect of moisture content and temperature of pressing on the quality of the oil was made. Changes in moisture content from 0.0 to 8.0 per cent and in temperatures of pressing from room temperature to 100° C. had no effect on the iodine number of the oil.

With beans of 4 per cent moisture content there is a gradual small increase in color before the break test with increase in temperature of pressing. The color after the break test is much lower than before the break test until the critical temperature of pressing (about 65° C.) is reached and the oil becomes a break oil. Then the color after the break test rises very sharply with increase in temperature of pressing.

The critical temperatures of pressing at which break oils result were raised as the moisture contents of the beans were reduced. Although these results may not be entirely comparable with those obtained in an oil mill where large hydraulic presses or oil expellers are used, the results show the important effect of moisture content of beans and temperature of pressing upon the quality and yield of the oil.

Literature Cited

(1) Am. Oil Chem. Soc., Official Methods of Chemical Analysis, 1929.
(2) Morse, W. J., U. S. Dept. Agr., *Farmers Bull.* **617** (1930).
(3) Pallauf, F., *Chem. Umschau, Fette, Oele, Wachse Harze*, **37**, 21-2 (1930).

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Removal of Positive Ions by Electroösmose Apparatus

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At rates of 20, 25, and 30 liters per hour, the positive ions sodium, calcium, and magnesium are satisfactorily removed by the apparatus studied. The removal of sodium is uniformly greater than calcium and magnesium, and removal of calcium greater than that of magnesium.

The relative concentration of negative ions in different parts of a typical electroösmose apparatus has been studied and reported by Bartow and Perisho (*1*). The experiments have been continued with positive ions, using the same apparatus and the same technic. The apparatus and the process used have also been described by Illig (*3*), Behrman (*2*), Marie (*4*), and Patin (*5*), and the description need not be repeated.

The object of the experimental work was to determine the rate of removal of some of the common positive ions and to study the effect, if any, that two or more ions might have on each other in a solution.

Experiments with Sodium, Calcium, and Magnesium

Sodium, calcium, and magnesium are the ions found in largest quantity in water which must be treated by some softening process; therefore the chlorides of these elements were chosen for the experiments. Solutions were made from chemically pure salts and distilled water. Tests were made with sodium chloride alone; calcium chloride alone; magnesium chloride alone; mixture of sodium chloride and calcium chloride; mixture of sodium chloride and magnesium chloride; mixture of calcium chloride and magnesium chloride; and mixture of sodium chloride, calcium chloride, and magnesium chloride.

In each trial the machine was run at three rates: 20, 25, and 30 liters per hour. Samples were taken from five parts of the machine: sample 1 from feed water; 2 from the third cell; 3 from the sixth cell; 4 from the ninth cell; and 5 from purified water (the overflow from the tenth cell). Thus fifteen samples were analyzed in each series; since each series was run in duplicate, a total of 210 samples was analyzed.

About 200 milligrams per liter of the positive ion were used in the experiments with the single salts; 100 milligrams each in the mixtures of two salts; and five equivalent weights when three salts were combined. In each sample the residue was determined by evaporation to dryness. Sodium was determined by the removal of the other ions and evaporation to dryness; calcium, by precipitation with ammonium oxalate and weighing as the oxide; magnesium, by precipitation with microcosmic salt and weighing as the magnesium phosphate.

Difficulties similar to those described by Bartow and Perisho (*1*) were experienced. The drip nozzles would plug up, and frequent adjustment was required to procure a uni-