BENEFICATION OF SOYBEAN OIL BY USE OF CENTRIFUGE

by

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I. INTRODUCTION

The United States is second only to Manchuria in the production of soybeans. One of the most striking developments in the United States in recent times is the rapid rise of the production of soybeans from three million bushels in 1907 to nearly forty million bushels in 1920. This large yield necessitated outlets other than as stock feed and so attracted the attention of the oil mills, which by 1929 began to be a major factor in the production of the crop. In 1926 2,500,000 pounds of soybean oil were produced, but in 1935 the crop of oil was 200,000,000 pounds. There are many uses of the oil, mainly as foodstuffs as a butter substitute, cooking oil, lard substitute, salad oil, and as a medicinal oil. The chief difficulty in the use of this oil lies in the fact that it becomes rancid soon after production.

This problem deals with the elimination of the various components of the soybean oil, causing the rancidity, by use of the supercentrifuge.

II. REVIEW OF LITERATURE

Soybean oil is very easily refined and deodorized, but on storage it rapidly turns rancid, acquiring a flavor described as grassy. Lewkowitsch ascribes the rancidity to the formation of free fatty acids in the presence of moisture, with enzymes acting as accelerators for the reaction. In crude oil the free fatty acids range around 0.5%, indicating considerable natural protection against hydrolysis in the sound beans. Fatty acids are catalysts for the auto-oxidation of glycerides, greater molecular weight giving greater effect. The composition of the oil is as follows:

GLYCERIDES	PER CENT
Linolenic	2.3
Linoleic	51.5
Oleic	33.4
Palmitic	6.8
Stearic	4.4
Arachidic	0.7
Lignoceric	0.1
Unsaponifiable	0.6

Nearly 90% of the fatty acids present are unsaturated with an iodine number of about 134.

The refining of the oil is usually carried out in five steps: neutralization, washing, bleaching, winterization, and deodorization. The only part of this process with which we are concerned though is the neutralization. Neutralization, as used here, applies to the separation of the soap stock from the neutral oil, the soap stock including free fatty acids, lye, and nearly all lipoids present. In the ordinary process this separation is carried out by first emulsifying the oil at 70° F with 10-14° Be. sodium hydroxide, and then on continued heat to around 160° F, the soap clots form and separate out after settling for 18-20 hours. This process is also carried out in a continuous method by the use of first a small beater and then neutralization by use of a high speed centrifugal machine. The oil in either case should be entirely free of lipoids after neutralization, the abscence being shown by the "Heat-break" test, which consists of freedom of soap stock in the form of floc when a sample of the oil is heated to 600° F. (2).

The use of the centrifuge is also carried on in

the removal of phospholipins from the oil. Phospholipins are substituted fats in which one molecule of fatty acid is replaced by a molecule of phosphoric acid united with a nitrogen base. Two of these phospholipins - lecithin and cephalin are found in soybean oil and are removed commercially by treating with steam and then centrifuging. The same result is also accomplised by emulsification with water and centrifuging, which also gives a good grade of non-break oil and crude phospholipins. (4).

III. EXPERIMENTAL

A. Purpose of Study

The purpose of this study was to determine the effect of centrifuging upon soybean oil as to lessening of rancidity and improvement of taste and quality.

B. Plan of Investigation

1. Secure samples of soybean oil.
2. Emulsify samples and run through centrifuge, varying the speed and the size of ring dam used.
3. Observe and record the following data on each sample:
   a. Speed
   b. Size of ring dam used
   c. Time of run
   d. Size of sample
   e. Amount of oil recovered

f. Appearance of oil immediately after recovery

g. Appearance of oil after settling for several days

h. Odor

i. Taste

4. Make "Heat-break" test on each sample of oil recovered

C. Materials

1. Soybean oil - The oil used was pressed from beans of the TOKIO (glycine hispia) variety, introduced from Tokio, Japan, 1901. Plants stout, erect, maturing in about 145 days; pubescence gray; flowers both purple and white, 70 to 75 days to flower, pods gray 40 to 50 mm long, 10 to 12 mm wide, 6 to 7 mm thick, 2-3 seeded, shattering little; seed olive yellow, 7 to 8 mm long, 6 to 7 mm wide, 5 to 6 mm thick; hilum pale; germ yellow; oil 18.4 per cent; about 134,000 to the bushel. (3).

2. Water - The water used for emulsification was ordinary tap water.

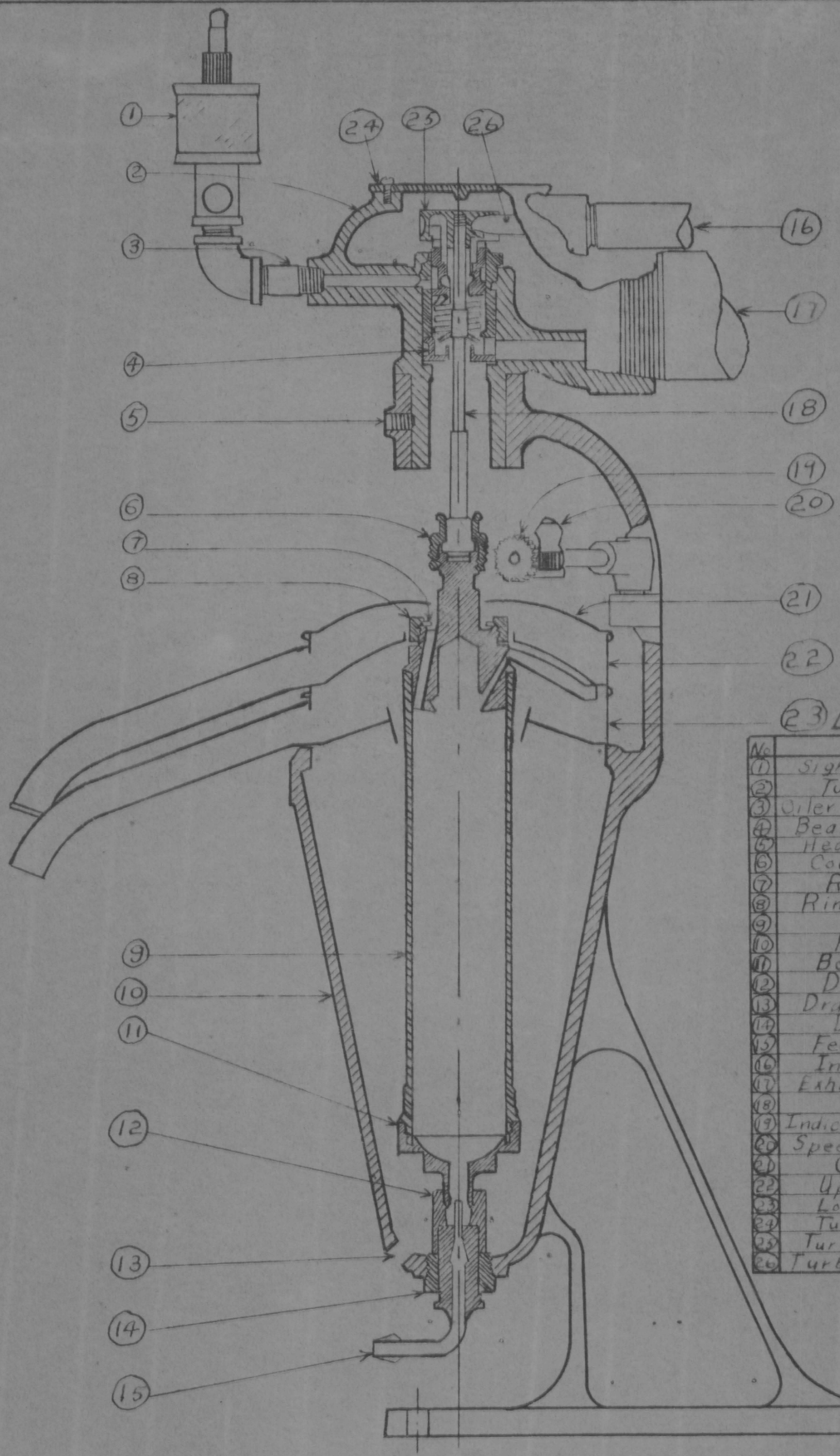
D. Apparatus

The supercentrifuge used was constructed by the Sharples Specialty Company, Type-41-23-8C-34, Serial Number 381A312, Maximum bowl speed of 50,000 revolutions per minute. The machine was set up as shown in figure 1. The bowl, 9 , has a total weight of 3.13 pounds, and an inner length of eight inches. The bowl has an outside diameter of 1.875 inches and as inside diameter of 1.75 inches. The bowl rotates around its center of gravity and is suspended from the turbine 25 by means of a flexible spindle 18 . This suspension of the bowl enables the machine to run with a minimum of power and a minimum of wear. The bowl, when turning at a speed of 40,000 revolutions per minute, generates a separating force of over forty-two thousand times the force of gravity.

The centrifuge is so designed that it may be operated to separate solids from liquids, or to separate liquids of different specific gravity. The method of operation is determined by the size of ring dam 7 used. The ring dam is a small brass washer which controls the amount of liquid allowed

to enter the upper cover 22 . The outside diameter of the ring dams is 1.4375 inches, but the diameter of the inner hole varies from 0.75 to 1.0 inches. The heavy liquid escapes into the upper cover while the lighter liquid escapes into the lower cover 23 . The liquid to be centrifuged is fed to the bowl from a glass funnel, connected by a rubber hose to the feed nozzle. The funnel is so arranged that a head of about two feet is maintained by the liquid to be fed in. Three sizes of feed nozzles were available, and used according to the rate of flow desired into the bowl.

A small glass bottle, holding about one quart, was provided for use in emulsifying the oil, and other appropiate vessels were provided to collect samples.



LEGEND

No.	NAME
1	Sight Feed Oiler
2	Turbine Head
3	Oiler Extension Piece
4	Bearing Oil Well
5	Head Set Screw
6	Coupling Nut
7	Ring Dam
8	Ring Dam Nut
9	Bowl Frame
10	Bowl Bottom
11	Drag Shell
12	Drain Plug Hole
13	Drag Nut
14	Feed Nozzle
15	Inlet Steam
16	Exhaust Steam
17	Spindle
18	Indicator End Wheel
19	Speed Indicator Gear
20	Cover Lid
21	Upper Cover
22	Lower Cover
23	Turbine Lid
24	Turbine Wheel
25	Turbine Nozzle

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ASSEMBLY DRAWING OF SUPERCENTRIFUGE

Scale : No scale | Date: APRIL 28, 1939 | Checked by: | Drawn by: W. D. Feagin

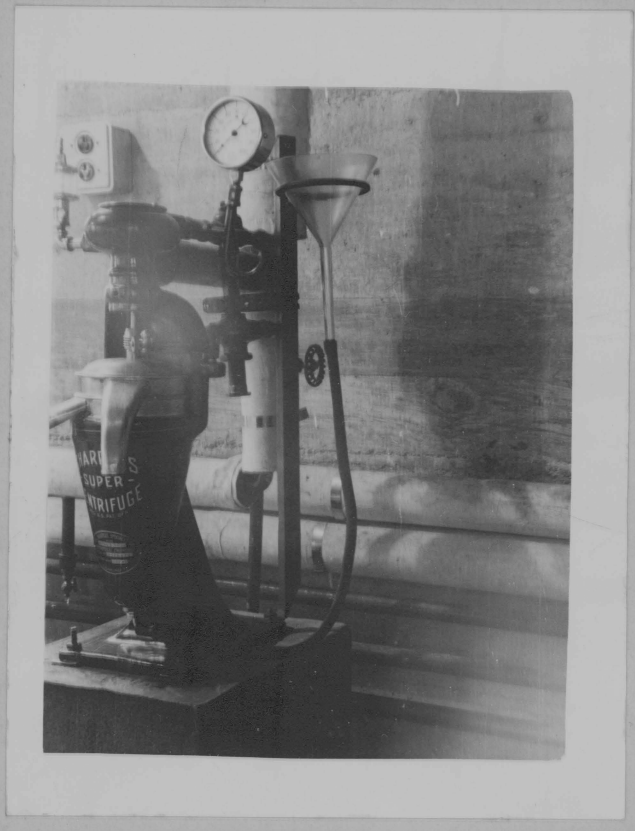

Figure 1

SET-UP

of

SUPERCENTRIFUGE

E. Method of Procedure

Oil - The oil was already pressed from the beans, and had acquired a rancid odor and grassy taste. Samples of the oil were measured, and emulsified by shaking with water.

Centrifuge - The centrifuge was started and the speed gradually increased until the desired speed was attained. The feed nozzle was then inserted, and water fed into the bowl until water began to escape from the upper spout. The emulsion was then slowly poured into the funnel, with continued shaking so that the oil and water would not separate. The liquids coming off at the upper and lower spouts were caught in vessels until no more oil would come from the lower spout. The machine was then cut off and allowed to come to rest, and the liquid remaining in the bowl caught in a vessel as the bowl stopped rotating. Samples were then taken of the precipitate in the bowl, and the taste and odor of the oil noted and recorded. The machine was then cleaned from oil for the next run.

Sampling - Samples of the oil recovered from the lower spout were then put under the "Heat-break" test by heating to 600° F in the electric oven. Other samples of the oil were then taken and the above procedure repeated at varying speeds and with different sizes of ring dams in place. Samples of the oil obtained under the various conditions were placed in 10 cc sample bottles and the bottles stored for future tests as to odor, taste, and color.

F. Tabulated Data and Results

Table I shows the effect of speed and changes in size of ring dams on the quality and quantity of oil recovered.

Table II shows a comparison of the oil recovered under the various conditions.

A sample of oil recovered by use of the #7 1/2 ring dam was rerun through the centrifuge. The separation on the second run was very poor as most of the oil was recovered, but the recovered oil contained a great deal of flocculent precipitate.

Table I

EFFECT OF SPEED AND CHANGES IN RING DAMS ON QUALITY AND QUANTITY OF OIL RECOVERED

Ring Dam No.	Speed r.p.m.	Size of Sample used cc	Size of Sample Recovered cc	Appearance of Discharge Bowl Liquid	Appearance of Discharge Lower Spout Liquid (Oil)	Appearance of Discharge Upper Spout Water
7	15,000	50	0	Creamy	Creamy	Cloudy
7	30,000	50	0	Creamy	Creamy	Cloudy
7	45,000	50	0	Creamy	Creamy	Cloudy
7 1/2	15,000	50	0	Creamy	Creamy	Cloudy
7 1/2	30,000	100	0	Creamy	Creamy	Cloudy
7 1/2	45,000	100	65	Lardy	Cloudy	Cloudy
8	15,000	100	0	Creamy	Creamy	Cloudy
8	30,000	100	0	Creamy	Creamy	Cloudy
8	45,000	100	40	Oily	Cloudy	Cloudy
8 1/2	15,000	100	0	Creamy	Creamy	Cloudy
8 1/2	30,000	100	0	Creamy	Creamy	Cloudy
8 1/2	45,000	100	32	Oily	Cloudy	Cloudy
9	45,000	1000	0	Creamy	Creamy	Creamy

Table # II

Comparison of Separations

Ring Dam Number	Inner Dia. of Ring	Heat Break Test	Appearance after 2 days	Separation
7 1/2	0.85	No Ppt.	Slight Ppt.	Good
8	0.867	No Ppt.	Medium Ppt.	Fair
8 1/2	0.890	Slight	Heavy Ppt.	Poor

IV. DISCUSSION

Precipitate. The cloudiness in the oil immediately after recovery was mostly due to entrapped air, caught during the rapid whirling of the oil in the bowl. This cloudiness disappeared after several days of settling, and a slight flocculent precipitate appeared in each of the samples. This precipitate seemed to be of the same nature as that recovered in the bowl, and therefore probably is a small portion of the soap stock that had been precipitated yet unremoved during the rapid passage of the oil through the bowl. The color of the oil after settling was somewhat lighter than the color of the original oil.

Odor. The odor of the oil was much improved by centrifuging, although the taste of the oil did not seem to differ greatly from the original taste. The precipitate in the bowl in each case had a very rancid odor.

Size of Batch. A centrifuge of this type can not be used on a continuous basis as the bowl fills

completely with the precipitated soap stock and prevents further feeding. The quality of the oil is also very poor and the removal of the soap stock is very slight as the bowl becomes full. The centrifuge can be used very satisfactorily though on a batch basis with the size of the bowl as the limiting factor.

Ring Dam Size. The ring dam, # 7 1/2, seemed to be the correct one to use for this separation as a greater percentage of the oil is recovered, and the precipitate in the bowl was entirely free from oil, and less precipitation in samples of this separation than in the others. It does not seem profitable to run the seperated oil through the centrifuge again as a very poor separation was obtained, although there seemed to be quite a bit of soap stock in the oil recovered. However, doubt that all of the material precipitated in the sample was soap stock was caused by the fact that samples of the oil gave only a very slight precipitate under the "Heat-break" test. The odor and taste of the oil seemed to be no better after the second run than before. Therefore, it seems that no benefits are obtained by running the oil twice

through the centrifuge.

Speed. Variations in speed below maximum seem to have little effect upon the separation except that the higher speeds seem to precipitate the soap stock better and more quickly in the bowl.

Feeding. The smallest nozzle was used to feed the emulsion to the bowl, as a better separation seemed to be effected when the oil was fed in more slowly. Some difficulty was experienced though as the nozzle tended to clog at times.

V. CONCLUSIONS

The results of this investigation indicate that:

1. The best separation of soap stock from the soybean oil is obtained by use of the # 7 1/2 ring dam.
2. The best separation of soap stock from the soybean oil is obtained at maximum speed.
3. The rancid odor of the soybean oil is eliminated to a large extent by the centrifugation of the oil.
4. The maximum yield of soybean oil is obtained by separation with the # 7 1/2 ring dam.
5. The grassy taste of the soybean oil is only slightly improved by centrifugation.
6. The color of the soybean oil is only slightly changed by centrifugation.
7. No additional benefits are obtained by

passing the soybean oil through the centrifuge a second time.

8. A centrifuge of this type can not be run on a continuous basis, when a separation of this type is being carried out.

9. It is definitely concluded, after centrifugation that most of the rancidity in soybean oil had been removed and that the oil was much more edible than formerly.

VI. SUMMARY

Samples of soybean oil were centrifuged in a Sharples supercentrifuge at speeds varying from 15,000 to 45,000 revolutions per minute and with ring dam sizes of # 7 to # 9 in use in order to determine the effect of centrifuging upon the rancidity, odor, color, and taste of the oil.

It was found that most of the rancidity could be removed, the taste improved slightly, the color only slightly changed, and the odor of the soybean oil improved very much. In general, the quality of the oil was made much more desirable although thirty-five per cent of the oil was lost during the prodess as soap stock.

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VIII. ACKNOWLEDGEMENTS

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