THE SOYBEAN

A PLANT IMMIGRANT
MAKES GOOD

By W. L. Burlison

Circular 461

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION AND EXTENSION
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SOYBEANS, nearly 40,000,000 bushels of which were grown in the United States in 1935, are by far the richest in protein and oil of any of our common crops. Besides furnishing excellent feed on the farm, soybeans are finding a wide use in industry. Various edible products of high nutritive value made from them are becoming available on the market. Soybean oil is used in paints, and in the fabrication of a long list of important commercial products. The protein from soybean meal is now receiving much attention as a raw material for the preparation of plastics, paper sizing, and glue.

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THE SOYBEAN
A Plant Immigrant Makes Good

By W. L. Burlison, Chief in Crop Production

The soybean, altho relatively new in America, is one of the oldest crops grown. Described in a Chinese book on materia medica, "Ben Tsao Gang Mu," written by Emperor Shen-Nung about 4,800 years ago, the soybean has been of prime importance in China and Japan since ancient times; and in value and variety of uses it is still the most outstanding legume grown in those countries. Production in Asia is concentrated in Japan, Korea, and two regions in the eastern part of China.

Trade in soybeans previous to 1908 was confined almost altogether to oriental countries, particularly China and Japan. Since about 1908, however, the usefulness of the soybean has been more generally appreciated in other countries, and an important international trade has developed.

Soybeans were introduced into the United States in 1804; yet about a hundred years later there were very few grown outside the southern states. By 1919 a fairly uniform development in soybean growing had occurred in the area east of the Mississippi river, and the crop had attained a considerable prominence in New England and in certain southern and western states. The total acreage of soybeans in the United States fluctuated rather noticeably, however, and by 1924 decreases had occurred in the eastern part of the country, particularly in New England and New York. In 1924, twenty-two states produced the bulk of soybeans grown in the United States, the total production of beans harvested as grain at that time being slightly more than 5 million bushels.

From 1924 to 1935, inclusive, production increased rapidly, figures for 1935 indicating a total of nearly 39,637,000 bushels of gathered beans. The more rapid increase of production has occurred in the corn-belt states, particularly in Illinois, Missouri, Indiana and Iowa. In 1935, Illinois produced about one-half of all the beans crushed in America.

Description of the Soybean

The soybean (Soja max) is a summer leguminous annual. Pods are from 1 to 2½ inches long and contain from 2 to 4 seeds. The stems, leaves, and seed pods are covered with short reddish-brown or
gray hairs. The root tubercles are large and abundant. There are many varieties of soybeans and literally hundreds of types and strains. The plants at time of active growth, or at about the flowering stage are shown on page 2. The flowers are small and inconspicuous, either white or purple, and are clustered in the axils of the leaves. The stems are branched, rather woody, and grow from 2 to 3½ feet or more in height. A mature plant about ready to be harvested for seed after the leaves have fallen is shown on page 16.

Soybean Culture

The soybean has a wide adaptation, being grown in many sections of the United States. Altho with the exception of cowpeas and lespedeza, it is more acid tolerant than any other legume crop grown in the corn belt, where most of the commercial beans are produced, it nevertheless responds well to soil treatment.

Cultivation of soybeans is not a complicated process, but is very similar to that for corn. Beans need a well-prepared seed bed in order to give them a good start ahead of the weeds. Soybeans can be grown on the average corn-belt farm with tools already in use for other crops. The combine, which threshes out the beans and leaves the straw on the land, has been a boon to the soybean grower as well as to the wheat producer. In Illinois there are about 3,000 combines (1935).

Soybeans in Illinois in 1935 averaged 18 bushels per acre. Cost records reported by the Illinois Agricultural Experiment Station show that soybeans were produced for 63 cents per bushel, as an average for the three year period, 1931-1933. These were low-cost years because of high yields and widespread combine harvesting.

Industrial Uses

Two decades ago the soybean was only a substitute in American agriculture. Today there are few if any crops that outrank it in interest and future possibilities. The need in 1920 was for more legumes in the rotation, more home-grown high-protein feeds in the feed bin, and substitutes in the rotation for red clover and oats. For these purposes the soybean was promising, and the early promise has been more than fulfilled. The real pre-eminence of the soybean, however, was to come later with the trend toward the development of industrial uses for agricultural products, the finding of new uses for old crops, and the creation of new markets for the farmer.

For a number of years the utilization of the increasing supply of soybeans did not worry the producer, for there was a steady demand

*These symbols refer to literature citations on page 15.
for seed with which to plant the expanding acreage. As the harvest of beans doubled and trebled, however, the demand for seed alone was not great enough to absorb all threshed beans. Other outlets had to be found if the crop were to continue its expansion.

The desired outlet was found in industrial uses for soybeans. Marked progress has been made in the development of such industrial uses during the past few years. It was not until 1929 that the absorption by soybean crushing mills began to be a potent factor in influencing production of the crop. Since 1929 the number of mills crushing beans has grown rapidly. At present about 35 soybean mills and a number of cottonseed oil mills are crushing soybeans for oil and oil meal; 20 concerns are manufacturing soybean food products; 15 mills are making soybean flour; and more than 50 factories are turning out various industrial products made from soybeans.

Disposition of the Domestic Crop

The demand for soybeans is now largely determined by three main uses: seed, livestock feed, and crushing. Distribution of gathered beans by uses and by amounts is shown in Table 1. Complete figures are not yet available for 1935.\textsuperscript{a} Considerable shifts in these amounts will no doubt be evident when final tabulations are made.

\textsuperscript{a}August, 1936.
Particular attention is called to the amount of beans crushed in 1930 (4,800,000 bushels) and the quantity of the oil (more than 37,000,000 pounds) produced from this reasonably large supply of beans. Most of the 110,000 tons of meal was used for livestock feed. The two products of the soybean which are attracting most attention are, of course, the oil and meal.

Out of a total factory consumption of 22,958,000 pounds of soybean oil in 1933, 489,000 pounds were used in compounds and shortening, 7,000 pounds in oleomargarine, 460,000 pounds in other edible products, 4,233,000 pounds in soap, 8,568,000 pounds in paint and varnish, 5,641,000 pounds in linoleum and oilcloth, 65,000 pounds in printing inks, and 2,626,000 pounds in miscellaneous products. Eight hundred sixty-seven thousand pounds represented "loss including foots." In 1933 the paint and varnish, linoleum and oilcloth industries consumed 61.88 percent of the total.

Two years later in 1935, out of a total factory consumption of 91,166,000 pounds of soybean oil, 52,452,000 pounds were used in compounds and vegetable shortenings, 1,740,000 pounds in oleomargarine, 9,421,000 pounds in other edible products, 2,549,000 pounds in soap, 13,003,000 pounds in paint and varnish, 4,816,000 pounds in linoleum and oilcloth, 52,000 pounds in printing ink and 1,665,000 pounds in miscellaneous products. About 5,000,000 pounds were accounted for by "loss including foots."

Products Derived From Soybeans

Many products are derived from soybeans grown in the United States. A list (compiled from letters received by the author) of such products actually being placed on the market in the United States and Canada during the latter part of 1931 includes the following food, feed, and industrial products:

<table>
<thead>
<tr>
<th>FOOD PRODUCTS</th>
<th>FOOD PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean flour</td>
<td>Rolls (10% soybean flour)</td>
</tr>
<tr>
<td>Soybean meal flour</td>
<td>Macaroni (20% soybean flour)</td>
</tr>
<tr>
<td>Refined edible soybean oil</td>
<td>Soybean muffins</td>
</tr>
<tr>
<td>Soybean salad oil</td>
<td>Soybean cookies</td>
</tr>
<tr>
<td>Chocolate bars (30% soybean flour)</td>
<td>Soybean doughnuts</td>
</tr>
<tr>
<td>Cocoa (up to 60% soybean flour)</td>
<td>Vegetable shortenings</td>
</tr>
<tr>
<td>Sausages (up to 50% soybean flour)</td>
<td>Infant foods</td>
</tr>
<tr>
<td>Bread (71/2% soybean flour)</td>
<td>Diabetic foods</td>
</tr>
<tr>
<td></td>
<td>Oleomargarine</td>
</tr>
<tr>
<td></td>
<td>Lard substitutes</td>
</tr>
<tr>
<td></td>
<td>Filled sweets</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Cake or meal
Commercial feed
Dairy feed
Hog chow

Paint
Varnish
Enamels
Oilcloth
Linoleum
Printers' ink

**FEED PRODUCTS**

Poultry chow
Dog chow
Calf chow
Rabbit chow
34% protein chow chow
Chick startena

**INDUSTRIAL PRODUCTS**

Glycerine
Celluloid
Lauxtex plastic wall coat
Lauxein waterproof soybean glue
Lauxein emulsifier
Soap
Core binders
Rubber substitutes
Plastics

This list is increasing constantly. Only the remarkable versatility of the soybean crop can explain the far-reaching development in its utilization; and extensive development seems to have just begun.

**Imports**

Imports of soybeans and soybean products into the United States have not been extensive, with the exception of imports of oil during the World War. Nevertheless, the amounts imported have represented sufficiently large proportions of the total supply to have an effect on the market.

The amount of soybeans imported into the United States has been fairly constant from year to year, but at no time particularly significant. The range for ten years, 1922-1931, was from about 59,000 in 1922 to over 72,000 bushels in 1929. Imports of beans returned in 1931 to about the 1922 figure, and have since remained near that level.

For a considerable period beginning in 1915, imports of soybean oil meal and cake were somewhat irregular. Upward trends seemed apparent, however, from 1925 until the levy of tariff duties on these two products for the first time in 1930. Imports of meal and cake reached approximately 86,000 tons in 1929; in 1931 they were only 20,000 tons, the amount obtainable from 825,000 bushels of beans.

Imports of soybean oil into the United States were greatly stimulated during the World War, when there was a shortage of vegetable oils and when some of the normal outlets in Europe were closed. Imports reached a total of nearly 336 million pounds in 1918. They have since declined irregularly but continually. The first marked drop occurred when the emergency tariff measure of 1921 took effect. As the increased tariff duties of 1930 became effective, further reduction in imports of soybean oil became apparent.

**Chemical Composition**

*Soybean Seed.*—Extensive studies have been made by agricultural experiment stations in this country on the chemical composition of
the soybean. The soybean differs from other legumes in nitrogen, oil, and starch content. The composition, by percentages, of soybeans and, for example, navy beans is approximately as follows:

<table>
<thead>
<tr>
<th></th>
<th>Moisture</th>
<th>Protein</th>
<th>Fat</th>
<th>N-free extract</th>
<th>Fiber</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybeans</td>
<td>9.9</td>
<td>36.5</td>
<td>17.5</td>
<td>26.5</td>
<td>4.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Navy beans</td>
<td>13.4</td>
<td>22.7</td>
<td>1.5</td>
<td>53.0</td>
<td>5.8</td>
<td>3.6</td>
</tr>
</tbody>
</table>

The differences in protein and fat between soybeans and navy beans are especially outstanding. A rather wide difference in the composition of different samples of soybeans is no doubt due to variety, soil and climate. It is of interest to note in this connection that the plant breeder, with his knowledge of genetics of the soybean, will no doubt be able to modify the composition materially and in such manner as to adapt it to various specific purposes.

*Soybean Oil.*—Baughman and Jamieson\textsuperscript{11} have done valuable work on the composition of soybean oil. They have characterized an oil expressed with an Anderson expeller from a large late variety known as Mammoth Yellow as follows:

- Sp. g. 25°/25° C. 0.9203; N\textsubscript{o}O 1.4736; Iod. No. (Hanus) 128.0; Sap. V. 189.5; Acid V. 0.5; Sat. Acids 11.5 percent; Unsat. Acids 83.5 percent (Iod. No. 148.7); Unsap. 0.6 percent. This oil was found to contain the following acids: Linolenic 2.2, linoleic 49.3, oleic 32.0, palmitic 6.5, stearic 4.2, arachidic 0.7, and lignoceric 0.1 percent. Calculated as glycerides: Linolenic 2.3, linoleic 51.5, oleic 33.4, palmitic 6.8, and stearic 4.4 percent.

Smith’s data\textsuperscript{22} indicate that soybean oil having an iodine number of 134 contains about 2 to 3 percent linolenic, 55 to 57 percent linoleic, and 26 to 27 percent oleic, with 9 to 10 percent saturated acids.

*Soybean Oil Meal.*—The composition\textsuperscript{15} of soybean oil meal varies somewhat, depending on the kind of beans and method of extraction. The following figures for the various components of the meal are based on analyses of six to sixteen samples, and were secured from mills using different processes of extraction. It is interesting to note the rather high calcium and phosphorus content of soybean oil meal.

<table>
<thead>
<tr>
<th>Component</th>
<th>Percent of total</th>
<th>No. of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry substance</td>
<td>91.85</td>
<td>12</td>
</tr>
<tr>
<td>Crude protein</td>
<td>41.41</td>
<td>16</td>
</tr>
<tr>
<td>Ether extract</td>
<td>5.05</td>
<td>16</td>
</tr>
<tr>
<td>Ash</td>
<td>5.70</td>
<td>16</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>7.50</td>
<td>12</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>6.63</td>
<td>16</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.273</td>
<td>8</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.454</td>
<td>6</td>
</tr>
</tbody>
</table>
Methods of Processing Soybeans

Expeller Method.—The oldest and most widely used method of extracting soybean oil in the United States is a continuous-pressure process in which expellers are used. This method has been used in Manchuria for centuries. The beans are crushed, dried to a moisture content of about 3 percent, and passed thru a steam-jacketed trough which heats the beans to about 150° F. before they reach the pressing cage of the expeller. This treatment renders the product more mobile without injuring the resulting oil for use in the manufacture of varnishes or impairing the digestibility of the nutrients in the meal. The expeller operates on the same principle as a household meat grinder. The ordinary working pressure is about six tons per square inch. The oil is pumped thru a rotary strainer on its way to storage, while the cake emerges in thin sheets that are broken up on a revolving cake breaker at the discharge end.

Hydraulic-Press Method.—During recent years the hydraulic-press has been used for processing beans. The beans are prepared in practically the same way as for the expellers just described, except that they must be heated to a higher temperature before being pressed. This process is not continuous and requires considerable hand labor for loading and unloading the presses.

Solvent-Extraction Process.—By this method the oil from the flaked or ground beans is dissolved with benzol or a special high-test gasoline, usually after the beans have been thoroly cleaned. The oil is then separated by distilling off the solvent, which is used over and over. Objection has been made that some of the solvent remains in the meal. Efficiently operated modern plants, however, can remove the last trace of the solvent. Oil obtained by this method possesses superior bleaching qualities and shows less refining loss. Likewise the meal is less susceptible to rancidity and shows better adhesive properties for utilization in the glue industry.

Industrial Use of Soybean Oil

First production of soybean oil in the United States seems to have been in North Carolina in 1910, and apparently in the Middle West in 1920 at Chicago Heights, Illinois. The quantity produced in this country at that time was not sufficient to be noted in the U. S. Census. Such marked advances have been made that in 1935 there were produced in this country more than 91,000,000 pounds of high-grade soybean oil.
The quality of soybean oil has varied so widely in the past that many users have been somewhat prejudiced against it because of lack of uniformity. Developments in processing and refining, however, have been rapid in recent years, and today the American product is fairly uniform in quality and is usually superior to imported oil.

The standard for raw soybean oil as promulgated by the National Soybean Oil Manufacturers Association is as follows:

**Tentative Specifications for Raw Soybean Oil**

<table>
<thead>
<tr>
<th>ASTM Designation</th>
<th>D 124-33T, Issued 1922, Revised 1933</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foots, percent</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Loss on heating at 105-110° C.</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Specific gravity at 15.5°/15.5° C.</td>
<td></td>
<td>0.924</td>
</tr>
<tr>
<td>Acid number</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Saponification number</td>
<td>190.00</td>
<td></td>
</tr>
<tr>
<td>Iodine number (Wijs)</td>
<td>131.00</td>
<td></td>
</tr>
</tbody>
</table>

Color—Not darker than a freshly prepared solution of 1.0 g. potassium dichromate in 100 ml pure H₂SO₄ (Sp. gr. 1.84) or its equivalent in iron-cobalt solution.

Soybean oil is adapted to a wide range of uses as is shown briefly in Table 2.

**Use of Soybean Oil in the Paint Industry**

No phase in the utilization of soybeans has been more striking than the development of methods for using the oil in paints and varnishes. Since Illinois was the leading soybean-producing state in 1924, it was only natural for the Illinois Agricultural Experiment Station to do what it could to promote the wider industrial utilization of soybean products.

It was six years ago, in 1930, that the Experiment Station launched this project. At the outset of the work it was found that paint companies were cautious in matters pertaining to the use of soybean oil. In fact, as Toch reported, soybean oil as a paint oil was practically unknown as recently as 1909. “Since that time,” Toch stated in 1921, “many investigators have published more or less conflicting articles concerning soya bean oil, and even the physical and chemical constants of soya bean oil vary to some extent. Owing to the fact that discordant results were continually obtained, it is only within the last year that it has been possible to state with some degree of certainty whether soya bean oil is a substitute for linseed oil, an adjunct to it, or neither.”

The above statement, written about fifteen years ago, was among the earlier ones in this country on the use of soybean oil in paints and varnishes. Between that time and the start of the Illinois experiments, successes and failures as this new development progressed were reported and discussed in a number of papers.
### Table 2—Adaptability of Soybean Oil to Use in Various Products

<table>
<thead>
<tr>
<th>Use</th>
<th>Probable Adaptation</th>
<th>Satisfactory Adaptation</th>
<th>Superior Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drying products:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint</td>
<td>To 50%</td>
<td>To 25-40%</td>
<td>To prevent yellowing</td>
</tr>
<tr>
<td>Varnish</td>
<td>To 20%</td>
<td>To add luster</td>
<td></td>
</tr>
<tr>
<td>Linoleum and oilcloth</td>
<td>To 20%</td>
<td>To give elasticity</td>
<td></td>
</tr>
<tr>
<td>Waterproof goods</td>
<td>To 25%</td>
<td>To prevent cracking</td>
<td></td>
</tr>
<tr>
<td><strong>Soap products:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hard soaps:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilet</td>
<td>If hydrogenated, to 25%</td>
<td>..........................</td>
<td></td>
</tr>
<tr>
<td>Household</td>
<td>If hydrogenated, to 20%</td>
<td>..........................</td>
<td></td>
</tr>
<tr>
<td>Laundry</td>
<td>Depends on price</td>
<td>In considerable amounts</td>
<td></td>
</tr>
<tr>
<td><strong>Soft soaps:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shampoos, etc.</td>
<td>Limited</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Automobile soaps, etc</td>
<td>Depends on price</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Edible products:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lard compounds</td>
<td>Depends on elimination of odor and rancidity</td>
<td>..........................</td>
<td></td>
</tr>
<tr>
<td>Cooking oils</td>
<td>If odor is permanently eliminated</td>
<td>..........................</td>
<td></td>
</tr>
<tr>
<td>Salad oils</td>
<td>In small amounts</td>
<td>In increasing amounts</td>
<td></td>
</tr>
<tr>
<td>Fountain drinks</td>
<td>Excellent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Candy</td>
<td>Fair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayonnaise</td>
<td>In small amounts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Margarine</td>
<td>In small amounts if properly treated</td>
<td>..........................</td>
<td></td>
</tr>
<tr>
<td><strong>Miscellaneous:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundry core oil</td>
<td>In large amounts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Printers' ink</td>
<td>Little change from present use</td>
<td>..........................</td>
<td></td>
</tr>
</tbody>
</table>

With this record as a background, the first of the Illinois Station studies on the use of soybean oil for paint purposes was begun in August, 1930. Paints were tested in which soybean oil constituted varying proportions up to 50 percent of the total vehicle (liquids) used in the paint. Direct comparisons were made with standard linseed oil paints. After five years of exposure, the paints made with soybean oil formulas are very satisfactory.

A large number of test panel exposures were put out for the first time during the spring of 1931. The purpose was to study, first, the behavior of paints differing primarily in their content of raw and treated soybean oil, and, in addition, to compare the effectiveness of different driers.

Interior as well as exterior paints were studied. The first of the panels coated with interior paints containing soybean oil were put up in the spring of 1931. The results of this set of panels are highly pleasing, and the work has been extended even farther. Rooms in the agricultural buildings on the University of Illinois campus have been painted with soybean oil paint. Today, after three years, the paint in these rooms is holding up in excellent shape. A number of buildings on the campus were painted with exterior soybean oil paints three years ago. These were inspected in July, 1935, and found to be
in good condition. The University of Illinois is now making liberal use of soybean paint.

From the exposure and other tests which have been made, we are convinced that soybean oil has a permanent place in the manufacture of paint. The results on the panels support the findings of other workers to the effect that 30 percent and more of the oil used in paint can be soybean oil when properly treated and when driers suited to this kind of oil are used.

This conviction is supported by results that are being obtained in the field. Many farm buildings in Illinois that have been painted with soybean oil paint have been inspected recently by the writer. This paint is giving satisfaction when properly handled and applied.

A number of organizations and paint manufacturers are interested in soybean oil for paint purposes and are doing much to promote intelligent use of it.

Gardner, a pioneer in the study of the use of soybean oil for paint purposes, gave the writer the following message under date of March 20, 1936.

I have been working on soybean oil for about twenty-five years, and on many occasions I have suggested its possibilities in exterior and interior paints for certain formulations, provided it was properly reinforced with other oils to give the desired physical properties. Proper treatment with other oils, in my opinion, will do away with the defects which otherwise might be encountered, such as "after softening" and mildew accumulation. It is believed, therefore, that soybean oil will occupy a most important position in the paint industry during the coming years.

**Soybean Oil as a Core Binder**

The use of soybean oil as a core binder has been under investigation for some years. Sefing and Surls report the following on the use of soybean oil as a core binder: "Soybean oil can be used satisfactorily as a core binder for foundry work. It produces cores that are on a par with those made from linseed oil." Casberg and Schubert present similar data on the suitability of soybean oil for core oil: "Raw soybean oil produced cores with an average tensile strength slightly higher than the average tensile strength of cores made from semi-refined or varnish soybean oil and compares favorably with the core oils now on the market."

**Other Uses for Soybean Oil**

In correspondence Joyce has written:

In treating the soybean oil our company operates a lecithin plant in which the lecithin or vegetable phosphatides is extracted from the oil. This lecithin is

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*The term "soybean oil paint" is used when the paint contains any soybean oil.
not only used in the medical profession as a nerve food, but is used in the
confectionary trade as a means of properly distributing icings and cake coatings.

Other uses where soybean oil may serve are suggested by Kishlar, as follows:

Millions of pounds of sulphonated castor oils are used each year in sprays, leather
processing, cloth printing and similar uses. A new sulphonated soyoil has been
developed which is proving to be of equal value at materially less cost... Several years ago attention was called to a young man who had had eczema
for many years. He was allergic to almost every form of protein. At the request
of a famous New York physician, a specially refined soybean oil was prepared.
The trouble in a few weeks cleared up. Many of the allergies disappeared. The
physician prescribed soybeans to scores more, with equally successful results. This
oil need not be taken like medicine, but is used in mayonnaise, French dressing,
Russian dressing or in any other way the usual cooking oils may be used.

Plastic Industry Uses Soybean Oil Meal

During the last six years there has been a dramatic rise of a new
industry — plastics — which gives promise of absorbing soybean products
in increasing amounts. It is said that the total value of plastics sold
to the consumer in 1935 amounted to approximately 200 million
dollars. This development seems like a modern miracle. Plastics are
found in furniture, wall panels, builders' hardware, electric fixtures,
ash trays, clocks, toilet articles, decorative stair fronts, automobile
parts, light switches, distributor cases, window frames, safety glass,
buttons, buckles, costume jewelry for clothing, and literally hundreds
of other little gadgets. The list is growing month by month.

The soybean is proving to be an excellent source of raw material
for the plastic industry. From a ton of soybeans are produced about
250 pounds of oil, and 1600 pounds of meal containing approximately
40 percent protein. Last year America produced about 40,000,000
bushels of soybeans. If 40 percent of this is protein, it is evident that
the soybean is an extensive source of plastic material. One automobile
company is reported to be constructing a plant for plastic manufacture
costing $5,000,000.

O'Brien has reported as follows on products derived from soybean meal:

The protein is extracted from the soybean meal at a high degree of purity. We have developed certain uses of protein in sizing of paper and in certain wax
emulsions for paper in waterproofing. The use of protein in sizing has de-
developed new possibilities in paper and paper manufacture and has permitted the
use of certain types of pulp which could not be used before for the manufacture
of paper that was to be sized. An extensive research program has been carried
on in the paper industry on the use of protein and in all I would say 2,000 tons
of paper have been made. We have also done some work on the use of protein
as a coating material instead of casein and also in replacing starch in beaters
and because of the improvement in the paper by the use of protein instead of
starch there are good possibilities in this direction. We have also done con-
siderable research on the use of protein or modified forms of protein as a resin and this field looks rather encouraging.

In the making of vegetable proteins there is a finely divided residue which is practically in colloidal form which is sold to manufacturers of dog foods, rabbit foods, etc., and there is also a coarser material which consists largely of the hulls of beans which is supplied to plastic manufacturers to take the place of wood flour in making various plastic articles such as telephone instruments, automobile instrument parts, cigar lighters, etc.

The vegetable protein from soya beans is also used in making the material called Gallalith which is prepared by taking strips of protein and exposing them in the presence of phenol fumes. This product, Gallalith, was formerly made in Germany in large quantities from milk casein.

Boyer has made the following comment concerning certain research problems now under way in the Edison Institute laboratory:

Another problem that we are investigating at present is the use of solvents other than the hydrocarbon type in the extraction process. We have produced extracted meal in this manner that has very unique and interesting properties. Altho we are not now at the point where we can safely predict anything we believe that an entirely new field can be opened up in this way for the soybean meal. One of our aims is to produce a synthetic fiber similar perhaps to the one now being produced in Italy from milk casein.

Glue From Soybean Oil Meal

Soybean glue, altho a newcomer in the plywood field, has found many uses in the last eight years. The tonnage approximates that of all other plywood glues combined. It is used for many forms of plywood, with the chief exception of gluing fancy veneers where stain is an important factor. The chief uses at present are for Pacific Coast fir and pine plywood, where it is used exclusively; box shooks in Eastern and Southern states; drawer bottoms, glass backs, etc., in the furniture field; and for laminating fiber boards.

Joyce describes soybean glue and its uses briefly as follows:

When the flour is taken from the meal the residue may be used as a stock food. The extracted meal is also used by our company as a source of vegetable protein. This protein known as Beta protein is used by the paper manufacturing trade as a sizing and a coating. The soybean protein is also used as a vegetable glue and is of particular interest to furniture manufacturers in the preparation of veneer work and by airplane manufacturers in making airplane propellers, etc. The glue being waterproof and of very great tensile strength, it is in great demand in the industry.

Soybean Oil Meal for Fertilizers

Soybean oil meal has not been used for fertilizer in this country to any considerable extent. It has been reported that Japan used from the year 1917 to 1932 from 1,000,000 to 1,500,000 tons of soybean oil meal per year in fertilizers. There may come a time when it will serve the American farmer in the conservation and improvement of his soils.
Further Investigation Needed

Much valuable research on soybeans and soybean products has been done in certain foreign countries and the United States, particularly in the fields of agronomy, genetics, and animal nutrition. Only within the last few years, however, have chemists and industrialists become deeply interested in the great possibilities of the soybean. The following are only a few of the many lines of study which need thorough and prompt investigation:

1. To study the composition of the soybean as affected by climate, soil and varietal differences.
2. To determine the effect of different methods of processing on the quality of the meal and oil.
3. To study in further detail the characteristics and composition of soybean oil.
4. To discover new industrial uses for the soybean and soybean products, and to improve the products which are now utilized by the industries.
5. To investigate methods of improving soybean oil with special reference to its use in the paint and varnish industry.
6. To further investigate the use of soybean oil meal in the manufacture of plastics.
7. To produce by breeding varieties better suited to the needs of industry.
8. To determine the economic place of the soybean in our agricultural and industrial program.

Literature Cited
