The Chemical Composition of Some High Iodine Number Soybean Oils[1]

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IN A previous communication (1) the authors reported the results of an examination of a soybean oil of abnormally low iodine number, namely 102.9. It was found that the low iodine number of this oil was associated with the complete reversal of the relative percentages of oleic and linoleic acids of the unsaturated acid fraction as compared with the same acids found in oils having iodine numbers of 124 and 127 from the same variety of soybeans.

During the past year several soybean oils having unusually high iodine numbers have been examined in the same manner and by the same methods (1) as were followed in the case of the previously-reported oil of low iodine number. The results of this examination are of considerable interest, especially from the standpoint of the relation between the iodine number and the composition of the glycerides and fatty acids present in these oils.

Varieties

The soybeans used in the present investigation represent a wild variety, and three cultivated varieties known as Seneca, Peking, and Illini, which yielded oils having iodine numbers of 151.4, 139.4, 137.8, and 131.6 respectively. The soybeans representing the wild variety were grown at Urbana, Illinois, during 1938. The seeds were small, dark brown or nearly black, and had a very low content of oil. Although the seed is unsuited for commercial production, it is of importance, because of the very high iodine number of the derived oil, in the breeding experiments which are being conducted by the Bureau of Plant Industry at Urbana. This variety has served as one of the parents in a number of crosses which have been made in an effort to obtain new strains of soybeans yielding oils of higher-than-average iodine numbers.

The sample of Seneca soybeans was supplied by Prof. R. G. Wiggans of the Department of Plant Breeding, New York State College of Agriculture. According to Professor Wiggans (2), this recently-named variety of soybeans represents a selection from No. 03654A, which was originally obtained from Mr. W. J. Morse of the U. S. Department of Agriculture in 1927. During the period 1927 to 1938 the original strain was purified and tested under conditions obtaining in New York State, and the seed is now being rapidly increased with the expectation that it will be grown widely throughout that region within a comparatively short time. It is a tall-growing, dark-podded, gray pubescent, early-maturing variety. Under New York State conditions it matures about 10 days later than Cayuga, but is materially earlier than the early strains of Manchu and Black Eyebrow. The yields have averaged about 25 per cent greater than Cayuga, which is the standard grain variety of New York State.

Seed representing the Peking variety was grown at Urbana, Illinois, during 1937. This variety is normally grown for hay, especially in the South, and is not ordinarily grown for crushing, because of its low oil content (ca. 16 per cent) and its black seed coat which necessitates dehulling prior to separation of the oil. As in the case of the wild variety mentioned above, and for the same reason, the Peking variety is being used in the genetic work at Urbana, Illinois.

For purposes of comparison the results obtained from the examination of a standard variety, namely, Illini, which was grown near St. Joseph, Illinois, in 1936, have been included.

Results

Data pertaining to the analysis of the soybeans are presented in Table I. In comparison with the hay and grain varieties, the wild soybean contains a very high percentage of protein and a very low content of oil. The abnormally high crude fiber content of the wild soybean is readily accounted for by the small size of the seed and consequently high ratio of seed coat to endosperm. It is also notable that the wild soybean and the Peking varieties have considerably higher phosphorus contents than is the case of Illini, which latter is fairly typical of the commercial varieties. The high content of phosphorus in the wild soybean should be borne in mind, as it will be considered later in connection with the phosphorus content of the oil derived from this bean. The content of calcium in the Seneca soybean is quite low in comparison with any of the other varieties reported here and is lower than the average commercial varieties.

TABLE I.—ANALYSIS OF SOYBEANS[1]

Constituent	Variety			
	Wild Beans	Seneca	Peking	Illini
	Percent[2]	Percent[2]	Percent[2]	Percent[2]
Nitrogen	7.92	6.19	6.03	6.86
Protein (Nx6.25)	49.50	38.69	37.69	42.87
Ash	6.88	4.94	5.90	4.78
Potassium	1.77	1.80	1.97	1.67
Phosphorus	0.912	0.717	0.830	0.522
Calcium	0.384	0.155	0.289	0.246
Crude Fiber	10.35	4.91	6.22	5.15
Polysaccharides as sucrose	5.62	9.39	7.33	6.67
Lipids (Skellysolve F)	5.07	19.14	18.05	20.45

[1] Data supplied by the Analytical Section of the U. S. Regional Soybean Industrial Products Laboratory.
[2] Calculated on a moisture-free basis.

A quantity of each of the four varieties of soybeans shown in Table I were flaked and extracted with Skellysolve F. The moisture content of the flaked beans as charged to the extractor was 5 to 8 per cent. The weight of flaked beans and the yield of oil shown in Table II are expressed on the moisture-free basis except in the case of the Illini variety which is reported on an air-dry basis.

TABLE II.—YIELD OF SOYBEAN OIL ON EXTRACTION

Variety	Weight of flaked beans	Yield of oil	
	Kilos	Kilos	Percent
Wild soybeans	34.309	1.961	5.72[1]
Seneca	10.000	1.912	19.12[1]
Peking	8.987	1.603	17.84[1]
Illini	8.500	1.200	18.45[2]

[1] Calculated on a moisture-free basis.
[2] Calculated on air-dry basis.

The physical and chemical characteristics of the four derived oils are shown in Table III. In addition to the high iodine and thiocyanogen numbers of the oil ob-

[1] Presented at the 30th annual meeting of the American Oil Chemists' Society, New Orleans, Louisiana, May 5 and 6, 1939.
[2] A cooperative organization participated in by the Bureaus of Agricultural Chemistry and Engineering and Plant Industry of the U. S. Department of Agriculture, and the Agricultural Experiment Stations of the North Central States of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

tained from the wild soybean, this oil is characterized by a high percentage of unsaponifiable matter. In contrast to the relatively high phosphorus content of the whole soybean, the phosphorus content of the oil is extremely low, and of the same order of magnitude as is normally observed in the case of alkali-refined oils. When this oil is heated by the official heat-break method in the presence of acid, the oil bleaches to a very light greenish yellow color and produces practically no break.

TABLE III.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE OILS

Characteristic	Wild beans	Seneca	Peking	Illini
Iodine number	151.4	139.4	137.8	131.6
Thiocyanogen number	87.4	85.1	84.5	81.3
Saponification number	188.8	193.0	191.2	193.5
Acid number	0.41	0.47	0.78	0.93
Diene number	0.0	1.6	0.0	0.74
Hydroxyl number	4.1	4.9	5.4	5.8
Unsaponifiable, percent	2.20	0.61	0.93	0.84
Break, percent	0.03	0.11	0.09	.....
Phosphorus, percent	0.0003	0.026	0.024	0.046
	70Y	70Y	70Y	35.Y
Color (1" cell)	6.74R	6.2R	6.64R	4.0R
Refractive index N_D^{25}	1.4759	1.4740	1.4741	1.4727
Specific gravity 25/25	0.9219	0.9203	0.9214	0.9195
Total acids, iodine number	157.6	144.5	143.4	138.0
Total acids, thiocyanogen number	89.4	87.0	85.9	84.0
Saturated acids, pct. det'd	13.6	12.14	12.7	13.2
Saturated acids, iodine number	2.0	1.6	3.4	2.9
Saturated acids, thiocyanogen number	2.2	2.2	3.0	3.3
Saturated acids, pct. corrected	13.5	11.92	12.4	12.7

The distribution of the fatty acids was calculated from the data given in Table III, and the results, together with those obtained in a similar previous study (1) on low iodine number oils, are shown in Table IV. The distribution of the unsaturated fatty acids was calculated on the assumption that the only unsaturated acids present in these oils were oleic, linoleic, and linolenic. According to Hilditch and Jasperson (3) normal soybean oils contain about 0.5 per cent of hexadecenoic or palmitoleic acid, $\Delta 9$:10-$C_{15}H_{29}COOH$, and it is not known to what extent this acid is present in soybean oils of abnormal iodine number.

TABLE IV.—COMPARISON OF THE IODINE NUMBER AND THE DISTRIBUTION OF FATTY ACIDS DERIVED FROM VARIOUS SOYBEAN OILS

Seed	Oil	Fatty acids				
			Unsaturated			
Variety, location, and crop year	Iodine number	Saturated	Total	Oleic	Lino-leic	Lino-lenic
		Pct.	Pct.	Pct.	Pct.	Pct.
Dunfield—Mo., 1936	102.9	12.0	88.0	60.0	25.0	2.9
Dunfield—Mo., 1937	124.0	13.2	86.8	34.0	49.1	3.6
Dunfield—Ind., 1937	127.3	13.1	86.9	34.8	46.0	6.0
Illini—Ill., 1936	131.6	12.7	87.3	27.7	53.7	5.9
Peking—Ill., 1937	137.8	12.4	87.6	24.4	56.2	7.3
Seneca—N. Y., 1938	139.4	11.9	88.1	24.7	55.4	8.0
Wild beans—Ill., 1938	151.4	13.5	86.5	11.5	63.1	12.1

Inspection of the data in Table IV indicates that there is a remarkable constancy in the ratio of saturated to unsaturated acids of these soybean oils, which appears to be wholly independent of the iodine number of the oil from which the acids were derived. Of the seven soybean oils having iodine numbers ranging from 102.9 to 151.4, the saturated acids were found to comprise 12.7±0.8 per cent and the unsaturated acids, 87.3±0.8 per cent of the total acids present. It is also to be noted that within the limits of experimental error, the percentages of linoleic and linolenic acids increase more or less regularly with increasing iodine numbers of the oils, whereas the reverse is true of the oleic acid, which decreases progressively with the increase in iodine numbers of the oils.

Although the data recorded in Table IV are limited with respect to the number of samples of soybeans which have been examined; nevertheless, in view of the randomness of their selection, they indicate that the distribution of the saturated and various unsaturated fatty acids in the soybean seed bears a definite relation to the iodine number of the oil, and their formation in these proportions is governed by a specific and relatively invariable biochemical process, independent of varietal, climatic, or pedological conditions. These observations may be summarized as follows:

(1) The ratio of saturated to unsaturated acids in soybean oil is fairly constant, irrespective of the total amount of oil present in the seed or of the iodine number of the extracted oil.

(2) The distribution of the unsaturated acids varies in a specific manner with the iodine number of the oil derived from the seed, but is independent of the total amount of acids which are formed during growth and maturation and stored by the seed in the form of various lipids.

LITERATURE CITED

(1) Dollear, F. G., Krauczunas, P., and Markley, K. S., Oil and Soap, *15*, 263-4 (1938).
(2) Wiggans, R. G. Private communication to the authors.
(3) Hilditch, T. P., and Jasperson, H., J. Soc. Chem. Ind., *57*, 84-87 (1938); *58*, 187-9 (1939).

Report of the Referee Board

FOR THE YEAR 1939-40 the Referee Board renewed 32 referee certificates, granted one new one and acted on a total of 35 applications. Again 5 check samples of crude cottonseed oil and 10 check samples of cottonseed were distributed, reports on the seed samples being tabulated by Mr. R. T. Doughtie of the Bureau of Agricultural Economics.

This report of the Referee Board's activity closely resembles those of the past few years. The Board wants to follow fairly stable procedures, but not to get into a rut, and will welcome constructive criticism of its work such as has come from referee chemists and other members at some of the annual meetings in the past.

There is some demand for new referee chemists who are especially qualified to examine and grade soybean oil and who are located in the centers of trading in that product. Interest in the problem has arisen among the traders, and there is no immediate prospect of a large volume of business for the chemists. It has been suggested that the Referee Board recommend laboratories to be interested in equipping themselves to perform the determinations which are now required and will in the future be required to grade soybean oil and also soybean meal. Obviously the problem is one of interest to our society, but it will be a difficult matter to incite the active interest of chemists and at the same time to be as critical of their qualifications and to subject them to as many collaborative tests as the standards of the Referee Board require. The problem will be inherited by the next Referee Board.

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