milling. Properly designed, it can be used unchanged for box press or Expeller operation. Improperly designed, it is little better than the ordinary hydraulic cooker. It obviates the necessity of a dryer in an Expeller setup.

Redesigned, if possible, as a continuous operation, it could be used with the Expeller as a one-piece milling unit ideally adapted to small, single-unit work.

As a batch, or as a continuous cooker, it gives results which will greatly improve the cottonseed mill process, box press and Expeller and certainly warrants more research and experimental work.

COMPOSITION OF A SOYBEAN OIL OF ABNORMALLY LOW IODINE NUMBER[1]

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Abstract

Oil from Dunfield soybeans (Columbia, Mo., 1936) having a very low iodine value, has been examined. Comparison of the constants of this abnormal oil with normal soybean oils indicates no significant differences except in iodine value and refractive index. Based on the calculated composition of the unsaturated acids, the abnormal oil appears to contain a higher percentage of oleic acid, and a lower percentage of linoleic and linolenic acids, than do normal oils. The lowered iodine value does not appear to be correlated with any increase in the stability of the hydrogenated product. The abnormality is attributed to an accumulation of unfavorable varietal, climatic, and pedological factors.

IN THE course of the investigation of the chemical composition of soybeans as affected by agronomic factors, there was encountered at the U. S. Regional Soybean Industrial Products Laboratory one lot of beans which yielded an oil of abnormally low iodine number. So far as the authors are aware, the iodine number of this oil, namely, 101.6, is the lowest ever recorded for an American cultivated variety of grain-type soybean.

The beans in question represent a Dunfield variety derived from Indiana seed and grown in test plots at Columbia, Missouri, during 1936. It is evident from the data[3] recorded in Table I that except for the iodine number of the extracted lipids, the beans appear to be similar in composition to those of the same variety and source grown at the same location during 1937. In view of this anomaly it was deemed of interest and value to determine, if possible, the chemical factors which were responsible for the abnormality in the iodine number of the oil derived from the 1936 crop.

TABLE I.—ANALYSIS OF DUNFIELD SOYBEANS GROWN AT COLUMBIA, MO.*

Analysis	1936 crop		1937 crop	
	As received	Moisture free	As received	Moisture free
Moisture, per cent	5.70	....	5.77	....
Nitrogen, per cent	6.42	6.81	6.02	6.39
Protein (N × 6.25), per cent	40.1	42.6	37.6	39.9
Ash, per cent	4.64	4.92	4.27	4.53
Potassium, per cent	1.68	1.78	1.58	1.68
Phosphorus, per cent	0.585	0.620	0.556	0.590
Calcium, per cent	0.276	0.293	0.196	0.208
Crude fiber, per cent	4.78	5.07	5.00	5.31
Polysaccharides as sucrose, per cent	6.12	6.49	7.32	7.77
Lipids (Skellysolve F), per cent	20.38	21.61	20.70	21.97
Iodine number of lipids	....	101.6	....	123.1

*Data supplied by the Analytical Section of this laboratory.

In order to accomplish this purpose 22.2 kg. of the dried flaked beans were extracted with Skellysolve F, yielding 4.22 kg. of solvent-free oil, equivalent to 20.06 percent of the moisture-free beans. A portion of the oil was forwarded to the Procter and Gamble Company to which the authors are indebted for the information concerning its refining, bleaching and hardening properties, while the remainder was analyzed in this laboratory. For purposes of comparison 5.54 kg. of dried (2.87 percent moisture) flaked beans, representing the 1937 Missouri crop, were likewise extracted with Skellysolve F. The yield of oil in this case amounted to 1.19 kg., or 20.8 percent of the moisture-free beans. For further comparison a sample of oil extracted from Dunfield soybeans grown at Lafayette, Indiana, was similarly examined.

Results of the examination of the three soybean oils are presented in Table II. From these results it is seen that, except for the low iodine number and refractive index of the oil obtained from the 1936 crop from Columbia, Missouri, all the oils appear to be quite similar and altogether normal for Dunfield beans. It is also evident from the results recorded in Table III that the percentages of saturated and unsaturated acids for all three oils are quite normal, as is also true of the thiocyanogen numbers. Only the iodine number of the oil from the 1936 crop of beans indicates any abnormality.

TABLE II.—ANALYSIS OF EXTRACTED OIL FROM DUNFIELD SOYBEANS

Analysis	Columbia, Missouri 1936	Columbia, Missouri 1937	Lafayette, Indiana 1937
Iodine number	102.9	124.0	127.3
Thiocyanogen number	78.0	79.6	80.2
Saponification number	191.1	193.2	192.1
Acid number	1.47	0.55	0.35
Diene number[4]	0.2	0.82	0.0
Hydroxyl number[5]	5.3	2.6	3.4
Unsaponifiable, per cent	0.84	0.70	0.66
Refining loss, per cent	3.2	....	....
Break, per cent	0.20	0.04	0.07
Phosphorus, per cent[6]	0.040	0.025	0.015
Color (1" cell)	70Y 4.2R	70Y 5.2R	70Y 3.5R
Refractive index, $n^{25}/_{D}$	1.4700	1.4722	1.4723
Specific gravity $^{25}/_{25}$	0.9159	0.9179	0.9182

[4]See reference (1). [5]See reference (2). [6]See reference (3).

[1]Presented at the 29th annual meeting of the American Oil Chemists' Society, New Orleans, La., May 12-13, 1938.

[2]A cooperative organization participated in by the Bureaus of Chemistry and Soils 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.

[3]Except where otherwise stated methods of analysis were those of the Association of Official Agricultural Chemists and the American Oil Chemists' Society.

TABLE III.—COMPOSITION OF THE FATTY ACIDS OF EXTRACTED OIL FROM DUNFIELD SOYBEANS

Composition	Columbia, Missouri 1936	Columbia, Missouri 1937	Lafayette, Indiana 1937
Total acids:			
Iodine number	106.6	128.8	130.7
Thiocyanogen number	81.4	81.3	83.8
Saturated acids, per cent determined	12.7	13.6	13.4
Iodine number	5.4	4.0	4.0
Thiocyanogen number	4.8	2.8	2.3
Saturated acids, per cent corrected	12.0	13.2	13.1
Unsaturated acids, per cent	88.0	86.8	86.9
Oleic acid, per cent	60.0	34.0	34.8
Linoleic acid, per cent	25.0	49.1	46.0
Linolenic acid, per cent	2.9	3.6	6.0

When, however, the distribution of the unsaturated acids is calculated from the constants given in Table III, it is seen that the proportion of oleic acid is almost twice, and of linoleic acid approximately half, as great for the 1936 as for the 1937 oils. Also the linoleic acid content of the unsaturated acid fraction is found to be lower for the 1936 oil than for either of the 1937 oils.

It might be presumed that the lower content of polyethenoid acids of the abnormal oil would result in an appreciable improvement of the stability of both the refined and hardened oils. However, the following quotation from the report of the examination of the oil by Mr. T. E. Hall, Procter and Gamble Company (4) indicates that this assumption is unwarranted. "The oil was caustic refined, filtered, and bleached. One part of the bleached oil was deodorized and one part was hydrogenated to 74 iodine value and deodorized in duplicate. The fresh flavors of both the unhardened and hardened oils was very good. The flavor of the aged unhardened oil was less oxidized than those of many deodorized soybean oils, but it still retained the characteristic soybean oil taste. The aged flavor of the hydrogenated oil was fairly good but no better than those from good grade bean oils of 135 iodine number."

DISCUSSION

The abnormal composition of the oil extracted from Dunfield soybeans grown at Columbia, Missouri, in 1936 appears to have resulted from an accumulation of unfavorable varietal, climatic, and pedological factors. The Dunfield variety of soybeans normally yields oil of an iodine number somewhat lower than the average for a variety like Manchu, and this tendency may have been intensified by the high temperature and the low rainfall which prevailed during the summer of 1936, and by the soil type found at Columbia, Missouri. The soil at Columbia, Missouri, consists of Putnam silt loam having an acid reaction and a hardpan layer beginning at a depth of 16 to 20 inches. According to Miller and Krusekopf (5), Putnam silt loam results in shallow rooting of plants and is not adapted to leguminous crops such as clover and alfalfa. These authors state, "In general, the yields obtained depend on the amount of rainfall, since the soil is too poorly drained to stand excess water and too impenetrable in the subsoil to stand drought well." In 1936 the May to August precipitation at Columbia, Missouri, amounted to 5.46 inches compared to 13.58 inches in 1937. Likewise, the mean maximum temperature for July and August, 1936, was 98.6° F. compared with 90.8° F. in 1937.

It has often been observed that environmental factors, such as temperature, moisture, and soil type, may be reflected in the metabolism of the growing plant and although the relative influence of each factor cannot be evaluated, the total effect has produced in the present case a considerable lowering of the degree of unsaturation of the fatty acids stored in the seed.

It is also worthy of note that of the 31 chemical and physical constants which were examined, only the iodine number and the refractive index of the oil indicated any abnormality in either the bean itself or the oil derived from it.

SUMMARY

Three samples of oil extracted from Dunfield soybeans having iodine numbers of 102.9, 124.0, and 127.3, respectively, were examined to determine what factors were responsible for the variation in the observed iodine numbers. The oils showed no significant differences in the percentages of unsaponifiable matter, total fatty acids, and saturated and unsaturated fatty acids. However, calculation of the composition of the unsaturated acid fraction indicated that the oil of lowest iodine number contained nearly twice the amount of oleic, and approximately half the amount of linoleic acid, of the other two oils. The abnormal proportions of the unsaturated fatty acids and the consequent lowered iodine value of the oil from the Dunfield beans grown in Missouri in 1936 appear to have resulted from an accumulation of unfavorable varietal, climatic, and pedological factors.

Contrary to expectations the low iodine value and relatively lower content of polyethenoid acids were not reflected in any very marked improvement in the stability of the refined or hardened oil over that of normal oil. In view of the composition of the abnormal oil reported here and the fact that of the 31 values of the physical and chemical constants only the iodine number and refractive index showed any marked abnormality, it might not be amiss to emphasize the necessity for caution in generalizing concerning the chemical composition of an oil on the basis of its so-called constants.

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