Technical Bulletin No. T-27 May, 1947

Yield and Chemical Composition of Oil From Castor Beans Grown in Oklahoma

by

J. E. Webster, H. Fellows, and H. F. Murphy

OKLAHOMA AGRICULTURAL EXPERIMENT STATION

Oklahoma Agricultural and Mechanical College

W. L. Blizzard, Director Louis E. Hawkins, Vice Director

Stillwater, Oklahoma

Contents

CASTOR BEANS COULD BECOME IMPORTANT "CHEMURGIC" CROP IN OKLAHOMA

Oklahoma-grown castor beans are fully equal in quality and percentage yield of oil to those grown elsewhere, the tests reported in this bulletin show. These tests were started in 1941 when it appeared that all oil crops might become valuable as a source of war *materiel.* Castor oil, though most commonly known as a cathartic, also has important industrial and engineering uses. The fact that Oklahoma once ranked as the largest domestic producer of castor beans made tests in this State especially significant. Although the wartime need has largely passed, the information presented in this bulletin indicates that castor beans could become a valuable minor crop in Oklahoma if conditions requiring domestic production should arise.

Yield and Chemical Composition of Oil From Castor Beans Grown in Oklahoma

J. E. WEBSTER, H. FELLOWS, and H. F. MURPHY[1]

The major objective of the study reported in this bulletin was to determine the oil yield in percent of castor beans produced in Oklahoma, and the quality of the oil.[2] Yields of beans and other similar data are available in a series of articles by Domingo and Crooks (2). An extensive bibliography is available in the book *Vegetable Fats and Oils* by Jamieson (3).

MATERIALS AND METHODS

Materials

The castor beans were grown on the Oklahoma Agricultural Experiment Station farms at Perkins and Stillwater and on the branch farms at Heavener (1 year) and Lone Grove. Other samples were grown on the U. S. D. A. experimental farm at Woodward. Also, for the year 1941, samples were secured from the U. S. D. A. plots on farms at Arapaho, Cherokee, and Greenfield, Oklahoma, and for 1942, samples were secured from Watonga as well. Growth conditions are discussed in the publications previously mentioned (2).

Only well filled mature beans were used for the test. Seed samples for any one year were allowed to stand until the spring or summer of the following year before tests were run, since this fitted in best with laboratory routine.

Methods

PREPARATION OF OIL FOR CHEMICAL ANALYSIS. The oil was cold pressed from the undecorticated seeds, in a Carver hydraulic press, using the larger cylinder that gave approxi-

[1] Respectively, Department of Agricultural Chemistry Research, Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma; U. S. D. A., Cooperating with the Botany Department, Kansas State College, Manhattan, Kansas; Department of Agronomy, Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma. The authors wish to acknowledge the help given by L. L. Ligon, Agronomy Department, Oklahoma, who supervised the planting and collection of seed during the later years of the test.

[2] At about the time plans were being made for starting this project, the United States Department of Agriculture embarked upon an extensive testing program in the Southwest and it became possible to utilize samples from their plots in Oklahoma for a part of the Oklahoma Station's testing program. Later, after the U. S. D. A. tests were discontinued, plantings were made by the Agronomy Department in various sections of the State, and the last year's results given in the tables are for seed from these plantings.

mately 5000 pounds of pressure per square inch. After pressing, the oil was centrifuged to remove suspended matter and then mixed with kaolin and filtered using suction. The filtered oil was clear and only faintly yellow when fresh, but darkened slightly on standing.

OIL ANALYSIS. The methods of analysis employed were essentially those given in the 1940 edition of the Methods of Analysis, Association of Official Agricultural Chemists (1). The Hanus iodine method was used because of its simplicity and the keeping quality of the iodine solution. Saponification numbers were determined as directed; however, for the acetyl value only 30 ml. of oil were used in place of the 50 ml. called for in the directions. The refractive indices were secured using an Abbe refractometer and the readings were made at 40° C.

WHOLE BEAN ANALYSIS. The percent of decorticated seed was secured by removing the testa by hand from a 15 to 20 gram sample and weighing the testae and kernels separately. These kernels were later used for the determination of ether extract. The figures for ether extract were secured by extracting duplicate 2-gram samples (dried at 105° C) of the kernels with petroleum ether (Skellysolve F) in a drip extractor until the loss in weight on re-extraction was negligible. The kernels were finely chopped for the first extraction and then finely ground in an agate-mortar before re-extracting. The values given in the tables for ether extract of the whole seeds disregard the oil content of the testae since this was found to be less than one percent. Moisture percentages were secured from the loss in weight of the two-gram samples after they were dried over night in an oven held at 105° C.

RESULTS

Tables I to IV show all of the analyses arranged by years. In addition they show the values according to variety, location of planting and any special treatment of the crop for that particular year. Tables V and VI are compilations of the data taken from the individual years and present average figures for the more important varieties and for the locations most used.

VARIETIES. Considering only the major varieties, Doughty 11 and Conner contained the largest percentages of oil, without any great difference between them. U. S. No. 7 contained slightly less oil than the other varieties but the differences were never large and did not exceed 2.5 percent. Generally considered, it is doubtful if there is any significant difference in the oil content of the varieties tested. One of the most interesting facts brought out is the remarkably close agreement between the chemical characteristics for oil from the different varieties; certainly no significant difference is shown by the results given in this bulletin.

LOCATION. Table VI, compiled from data given in tables I to IV, gives some idea of the effect of location. The figures clearly show there is no appreciable variation in the *quality* of oil between locations. In fact, the most noteworthy point is the remarkably narrow range for the oil characteristics. The oil *yield,* however, shows a greater variation with respect to location. Stillwater samples are definitely somewhat lower in percentage of oil, especially as compared to the samples from Woodward. The much lower values at Stillwater in 1944 can probably be traced to a severe local drought that year. In spite of this somewhat lower value of oil, the percentage is still quite high and compares favorably with published values.

DATE OF PLANTING. A date of planting test was made for one year with the Conner variety. The oil samples from the four dates were rather similar in composition (Table II). Greater differences might have appeared if some of the plantings had resulted in immature seeds, but the samples taken for analysis were all fully matured.

SPACING OF HILLS. Table II also contains data on seed from two different spacings. The yield of oil and oil characteristics are nearly identical for two spacings. Within the limits of these tests, spacing of hills was not a factor in altering the percentage of oil or the oil characteristics.

NUMBER OF PLANTS PER HILL. Results are for one year only and are shown as a part of Table III. The growing of one, two, or three plants per hill has not appreciably changed either the oil content or the quality of the oil. Here again the samples are too few to make any certain statement but the results are in keeping with the other analyses which indicate that oil from matured beans is quite constant in composition.

STAGE OF MATURITY. Some of the samples from the 1943 crop were harvested at three stages of maturity and the data are given as a part of Table III. Only one sample showed any marked variation; in Kentucky 38 the oil content was reduced about three percent when all of the beans were harvested after a heavy frost.

ANNUAL VARIATIONS. Separate tables are not given to show annual variations but they may be found in part by referring to tables V and VI. It is apparent that, with the exception of the Stillwater 1944 samples, annual variations are small. Here, as previously mentioned, the drought adversely affected the percentage of oil but did not greatly alter the oil characteristics.

COMPARISON OF RESULTS

Table VII compares the values recorded in this bulletin with those reported in the literature. The results for Oklahoma compare favorably with those reported from other areas, although several of the extreme values reported herein are slightly beyond the limits given by Jamieson. The iodine numbers fall toward the lower limits of reported values, but with this exception Oklahoma-grown oils compare favorably with those grown elsewhere and should prove acceptable for any use.

SUMMARY

1. The yield of oil from Oklahoma-grown castor beans was nearly 50%, and compared favorably with that from other sections as recorded in the literature.

2. Chemical determinations of certain oil characteristics showed that the oil was average for such values and was of good quality.

3. Factors such as variety, date of planting, date of harvesting, spacing in the hill, and spacing in the row, did not materially alter the percentage or quality of oil.

4. Location within the State slightly influenced the oil percentages but not the quality of oil.

5. Characteristics of the oil were normal with the exception of the iodine number, which generally was slightly below the average values reported for other locations by Jamieson.

6. Extreme drought, recorded for one year at Stillwater, somewhat reduced the percentage of oil but did not greatly alter the oil characteristics.

LITERATURE CITED

1. Association of Official Agricultural Chemists.
1940 Official and Tentative Methods of Analysis. 5th Ed. 710 pp.

2. Domingo, W. E. and D. M. Crooks.
1945 Investigation with the Castor Bean Plant; I Adaptation and Variety Tests. II Rate-of-Planting and Date-of-Planting Tests. III Fertilizers, Clipping, Methods of Planting, and Time of Harvest.
J. Am. Soc. Agron. 37:750-762, 812-820, and 910-915.

3. Jamieson, G. S.
1943 Vegetable Fats and Oils.
2nd Ed. 508 p. Reinhold Pub. Co., New York.

TABLE I.—A Comparison of the Chemical Characteristics of Oil Taken From Several Varieties of Castor Beans Each Grown at Different Locations in Oklahoma (1941).

Location	Decorticated Seed %	Decorticated Seed H_2O%	Ether Extract % Decorticated Seeds	Ether Extract % Whole Seeds*	Oil Analyses Ref. Index	Sap. No.	Acetyl Value	Iodine No.
			Conner (Mo. seed)					
Stillwater	78.2	5.74	63.57	49.76	1.4724	179.34	150.17	82.02
Stillwater	78.0	4.41	63.79	49.75	1.4722	180.50	147.79	82.86
Perkins	78.5	6.23	63.74	50.04	1.4725	180.29	148.97	82.86
Arapaho	77.9	4.56	65.61	51.11	1.4725	180.70	146.54	83.36
Cherokee	78.9	4.96	62.29	49.15	1.4726	181.00	146.00	80.01
Greenfield	78.7	5.17	63.87	50.25	1.4727	180.13	148.84	82.43
Woodward	77.3	4.70	67.32	52.04	1.4730	180.36	148.68	81.68
Average	78.2	5.11	64.31	50.35	1.4726	180.33	148.14	82.25
			Doughty No. 11					
Stillwater	76.3	4.33	63.90	48.76	1.4721	180.21	148.47	83.08
Perkins	76.6	6.80	66.61	51.07	1.4726	181.96	146.48	93.08
Cherokee	77.6	5.48	61.96	48.09	1.4724	180.69	145.93	83.04
Greenfield	77.0	4.76	62.32	48.02				
Woodward	77.0	3.97	69.68	53.58	1.4725	180.37	148.75	84.28
Average	76.9	5.07	64.89	49.90	1.4724	180.81	147.41	83.37
			U. S. No. 7					
Stillwater	76.5	4.31	62.59	47.88	1.4720	179.77	148.70	82.68
Perkins	76.9	6.18	64.25	48.31	1.4716	183.13	146.44	82.79
Cherokee	78.1	5.18	60.18	47.01	1.4723	180.87	145.34	83.10
Greenfield	76.2	5.31	62.56	47.75	1.4730	179.75	147.75	83.13
Woodward	76.4	3.83	61.82	47.24	1.4730	180.51	146.05	82.46
Average	76.8	4.96	62.28	47.64	1.4724	180.81	146.86	82.83

* These values were secured by calculation using the decorticated percentages given in this table.

TABLE I.—(Continued).

Location	Decorticated Seed %	Decorticated Seed H_2O%	Ether Extract % Decorticated Seeds	Ether Extract % Whole Seeds*	Oil Analyses Ref. Index	Sap. No.	Acetyl Value	Iodine No.
Kentucky No. 38								
Stillwater	76.4	4.64	62.20	47.52	1.4730	179.97	147.66	83.57
Perkins	76.3	5.55	64.59	49.29	1.4726	179.75	147.72	83.37
Cherokee	77.6	4.82	62.52	48.52	1.4730	180.63	145.59	83.56
Greenfield	76.3	4.81	64.22	49.00	1.4730	181.33	149.23	83.01
Average	76.4	5.00	63.52	48.55	1.4729	180.12	147.12	83.51
Conner (Texas seed)								
Stillwater	78.8	4.35	63.94	50.38	1.4728	178.92	147.98	85.93
Perkins	77.7	6.04	65.00	50.51	1.4729	180.26	149.25	82.94
Cherokee	78.8	5.03	63.21	49.81	1.4733	181.76	145.09	83.65
Greenfield	79.5	5.05	66.02	52.49	1.4729	181.74	146.89	84.32
Woodward	77.5	3.84	69.92	54.12	1.4728	180.50	148.02	83.36
Average	78.9	4.86	65.62	51.46	1.4729	180.64	147.45	84.04
U. S. No. 4								
Stillwater	77.9	5.52	65.17	49.99	1.4730	179.17	146.98	83.50
Perkins	76.9	6.38	63.25	49.54	1.4730	180.70	147.52	83.60
Cherokee	78.0	4.69	61.87	48.26	1.4721	181.66	143.31	84.04
Greenfield	77.4	4.88	65.61	50.78	1.4728	179.93	146.78	83.81
Woodward	77.7	4.46	63.46	49.31	1.4725	180.63	145.53	83.47
Average	77.6	5.19	63.67	49.58	1.4727	180.42	146.02	83.68
San Benito								
Stillwater	79.9	5.81	63.94	49.81	1.4728	179.07	150.81	82.91
Perkins	77.2	5.54	66.67	51.47	1.4729	179.49	150.47	82.84
Cherokee	78.9	4.64	62.72	49.49	1.4726	181.37	143.96	83.37
Greenfield	78.8	5.20	63.08	49.69	1.4729	179.24	149.35	83.55
Woodward	78.0	3.66	69.41	54.14	1.4730	180.49	150.47	83.54
Average	78.2	4.97	65.11	50.92	1.4728	179.93	149.01	83.24

* These values were secured by calculation using the decorticated percentages given in this table.

TABLE II.—A Comparison of the Chemical Characteristics of Oil Taken From Several Varieties of Castor Beans Each Grown at Different Locations in Oklahoma (1942).

Location	Decorticated Seeds		Ether Extract %		Oil Analyses			
	%	H_2O %	Decort. Seeds	Whole Seeds*	Ref. Index	Sap. No.	Acetyl Value	Iodine No.
			Conner					
Lone Grove	73.90	5.21	64.59	47.73	1.4730	180.11	145.90	84.30
Lone Grove	77.64	5.29	63.17	49.05	1.4724	178.48	147.19	84.42
Stillwater 4/1**	76.68	4.52	65.64	50.32	1.4730	179.56	146.46	84.42
Stillwater 4/15	75.93	3.97	64.35	48.86	1.4730	179.65	146.85	84.33
Stillwater 5/1	76.32	4.11	64.73	49.41	1.4733	179.60	148.15	84.27
Stillwater 5/15	76.60	3.80	64.46	49.38	1.4731	179.74	147.92	83.57
Stillwater	73.80	3.76	64.70	47.68	1.4730	179.74	145.68	84.49
Stillwater 12"†	76.70	4.06	64.00	49.10	1.4731	179.73	146.90	83.69
Stillwater	76.19	4.35	65.08	49.59	1.4732	179.89	145.68	83.78
Stillwater 60"†	77.08	3.81	63.74	49.14	1.4730	179.68	146.60	84.23
Watonga	76.70	3.69	69.27	53.14	1.4732	179.75	148.01	83.76
Watonga	75.40	3.13	68.03	51.30	1.4730	179.34	148.04	83.40
Heavener	73.42	4.30	47.17	34.63	1.4730	179.35	148.47	83.76
Average	75.88	4.15	63.76	48.41	1.4730	179.59	147.09	84.03
			Doughty No. 11					
Lone Grove	76.08	4.95	66.73	50.77	1.4732	179.83	145.59	84.33
Stillwater	75.64	4.19	65.20	49.32	1.4729	179.61	147.69	83.28
Watonga	74.75	3.02	70.77	52.91	1.4728	179.85	148.22	84.18
Average	75.49	4.05	67.57	51.00	1.4730	179.76	147.17	83.93

TABLE II.—(Continued).

Kentucky No. 38								
Lone Grove	75.33	5.25	63.97	48.19	1.4731	179.92	145.27	84.41
Stillwater	75.85	4.24	66.06	50.11	1.4731	180.15	145.74	84.59
Watonga	75.90	3.29	68.19	51.75	1.4730	179.36	148.95	83.74
Average	75.69	4.26	66.07	50.02	1.4731	179.81	146.65	84.25
U. S. No. 7								
Lone Grove	77.59	5.29	62.90	48.31	1.4730	180.06	144.39	84.56
Stillwater	73.70	3.92	64.34	47.41	1.4730	180.17	144.51	84.28
Watonga	76.28	3.82	67.12	51.20	1.4730	178.64	148.06	84.13
Average	75.86	4.34	64.79	48.97	1.4730	179.62	145.65	84.32
U. S. No. 4								
Lone Grove	76.20	4.30	62.52	47.65	1.4731	179.91	144.98	84.26
Stillwater	75.60	3.68	63.55	48.04	1.4730	----	----	84.27
Watonga	76.05	3.07	68.92	52.42	1.4729	179.71	145.93	84.09
Average	75.95	3.68	65.33	49.37	1.4730	179.81	145.39	84.21
Small seeded beans (Unnamed)								
Stillwater	74.40	3.97	63.11	46.95	1.4732	179.29	148.17	84.29

* These values were secured by calculation usinng the decorticated percentages given in this table.
** Date of planting. † Distance apart of plants.

TABLE III.—A Comparison of the Chemical Characteristics of Oil Taken From Several Varieties of Castor Beans Each Grown at Different Locations in Oklahoma (1943).

Location	Decorticated Seeds		Ether Extract %		Oil Analyses			
	%	H_2O %	Decort. Seeds	Whole Seeds*	Ref. Index	Sap. No.	Acetyl Value	Iodine No.
Conner								
Stillwater**	77.55	3.89	64.70	50.17	1.4732	180.46	146.88	82.78
Stillwater†	78.28	3.87	64.95	50.84	1.4734	180.07	147.88	82.73
Stillwater††	78.39	3.92	64.96	50.92	1.4735	180.50	146.85	82.80
Woodward 1 plant†††	78.46	4.57	63.60	49.90	1.4725	179.94	148.79	83.70
2 plants	78.50	4.37	64.58	50.70	1.4730	179.62	146.73	82.91
3 plants	78.28	5.25	63.72	49.88	1.4730	179.40	150.21	83.92
Lone Grove	76.35	4.28	66.72	50.94	1.4728	181.09	146.82	82.79
Average	77.97	4.31	64.75	50.48	1.4731	180.15	147.74	83.18
Kentucky No. 38								
Stillwater**	76.00	4.08	63.75	48.45	1.4728	179.99	148.71	83.58
Stillwater †	76.80	4.10	64.20	49.31	1.4728	179.78	150.55	84.14
Stillwater††	75.79	4.67	62.10	47.07	1.4728	179.70	147.11	83.66
Lone Grove	75.36	4.40	64.89	48.90	1.4730	179.01	148.87	82.88
Average	75.99	4.31	63.73	48.43	1.4729	179.80	148.80	83.57
Doughty No. 11								
Stillwater**	75.25	4.05	66.46	50.01	1.4725	180.61	154.80	83.53
Stillwater†	76.85	4.29	65.65	50.45	1.4725	180.29	150.27	82.85
Stillwater††	76.26	3.58	66.38	50.62	1.4729	178.78	148.91	83.91
Average	75.12	3.95	66.16	50.36	1.4726	179.89	151.33	83.43
U. S. No. 7								
Lone Grove	77.90	3.84	64.62	50.34	1.4735	179.63	150.54	83.84

* These values were secured by calculation using the decorticated per centages given in this table.
** Harvested before any shattering could occur, before and after frost.
† Harvested when shattering was conspicuous, before and after frost.
†† Harvested only once and then after a heavy frost.
†††Indicates number of plants per hill.

TABLE IV.—A Comparison of the Chemical Characteristics of Oil Taken From Several Varieties of Castor Beans Each Grown at Different Locations in Oklahoma (1944).

Location	Decorticated Seeds		Ether Extract %		Oil Analyses			
	%	H_2O %	Decort. Seeds	Whole Seeds*	Ref. Index	Sap. No.	Acetyl Value	Iodine No.
Conner								
Woodward	77.61	4.11	64.08	49.73	1.4728	180.80	149.54	84.88
Stillwater	77.11	4.65	58.42	45.06	1.4734	179.79	151.72	84.65
Lone Grove	76.38	3.01	65.76	50.23	1.4731	179.46		83.38
Average	77.03	3.92	62.75	48.34	1.4731	180.02		84.30
Doughty No. 11								
Woodward	77.66	4.03	66.55	51.68	1.4728	180.14	148.68	84.87
Stillwater	76.26	4.41	59.25	45.18	1.4732	179.90	145.51	83.13
Lone Grove	76.50	3.24	67.38	51.55	1.4728	179.52	143.25	84.24
Average	76.81	3.89	64.39	49.47	1.4729	179.85	145.81	84.08
Kentucky No. 38								
Woodward	77.00	4.51	63.40	48.81	1.4732	180.62	150.60	83.97
Lone Grove	75.88	3.08	66.01	50.09	1.4728	179.80	141.34	84.79
Average	76.44	3.80	64.70	49.45	1.4730	180.21	145.97	84.38

* These values were secured by calculation using the decorticated percentages given in this table.

TABLE V.—A Comparison of the Chemical Characteristics of Oil Pressed From Several Varieties Grown at Three Locations in Oklahoma (1941-1944).

Year	No. of Samples**	Decorticated Seeds		Ether Extract %		Oil Analyses			
		%	H_2O %	Decort. Seeds	Whole Seeds*	Ref. Index	Sap. No.	Acetyl Value	Iodine No.
				Conner					
1941	(12)	78.55	4.98	64.97	50.91	1.4728	180.44	148.85	83.15
1942	(13)	75.88	4.15	63.76	48.41	1.4730	179.59	147.09	84.03
1943	(7)	77.97	4.31	64.75	50.48	1.4731	180.15	147.74	83.18
1944	(3)	77.03	3.92	62.75	48.34	1.4731	180.02		84.30
Average		77.36	4.34	64.06	49.54	1.4730	180.05	147.89	83.66
				Doughty No. 11					
1941	(5)	76.90	5.07	64.89	49.90	1.4724	180.81	147.41	83.37
1942	(3)	75.49	4.05	67.57	51.00	1.4730	179.76	147.17	83.93
1943	(3)	75.12	3.95	66.16	50.36	1.4726	179.89	151.33	83.43
1944	(3)	76.81	3.89	64.39	49.47	1.4729	179.85	145.81	84.08
Average		76.08	4.24	65.76	50.18	1.4727	180.08	147.93	83.70
				Kentucky No. 38					
1941	(5)	76.40	5.00	63.52	48.55	1.4729	180.12	147.45	83.51
1942	(3)	75.69	4.26	66.07	50.02	1.4731	179.81	146.65	84.25
1943	(4)	75.99	4.31	63.73	48.43	1.4729	179.80	148.80	83.57
1944	(2)	76.44	3.80	64.70	49.45	1.4730	180.21	145.97	84.38
Average		76.13	4.34	64.51	49.61	1.4730	170.99	147.22	83.93

* These values were secured by calculation using the decorticated percentages given in this table.

** Indicates the number of samples used in calculating the values given in each line.

TABLE VI.—A Comparison of the Chemical Characteristics of Oil From Three Major Varieties of Castor Beans Grown at Different Locations in Oklahoma (1941-1944).

Location† and Year	No. of Samples**	Decorticated Seeds		Ether Extract %		Oil Analyses			
		%	H_2O %	Decort. Seeds	Whole Seeds*	Ref. Index	Sap. No.	Acetyl Value	Iodine No.
Stillwater									
1941	(8)	77.60	4.89	63.51	49.23	1.4725	179.62	148.57	83.38
1942	(13)	75.74	4.03	64.54	48.87	1.4731	179.74	146.70	84.11
1943	(9)	76.69	3.53	64.79	49.76	1.4729	180.02	149.11	83.33
1944	(2)	76.94	4.53	58.84	45.13	1.4733	179.81	148.62	83.89
Woodward									
1941	(7)	77.07	4.23	66.53	51.27	1.4728	180.26	148.10	83.11
1942									
1943	(3)	78.41	4.73	63.97	50.16	1.4728	179.65	148.58	83.84
1944	(3)	77.42	4.20	64.68	50.07	1.4729	180.52	148.94	84.57
Lone Grove									
1941									
1942	(6)	76.12	5.05	63.98	48.62	1.4730	179.71	145.55	84.38
1943	(3)	76.53	4.17	65.21	50.06	1.4731	179.91	148.74	83.17
1944	(3)	76.25	3.11	66.38	50.62	1.4728	179.59		84.14

* These values were secured by calculation using the decorticated percentages given in this table.

** Indicates the number of samples used in calculating the values given in each line.

† Averages for the different locations are not given because of the irregular number of samples for each place and year, nor are locations included where a crop was grown for only one year.

TABLE VII.—A Comparison of the Chemical Characteristics of Castor Bean Oil From Seeds Grown in Oklahoma and the Average Values for Those Grown in Other Regions as Given by Jamieson (3).

	Oklahoma	Jamieson
Decorticated seed (percent)	73.42-79.9	70.0-80.0
Ether extract (oil) (percent)	*45.06-55.8	35.0-55.0
Refractive index	1.4720-1.4735	1.4659-1.4730
Saponification number	178.4-183.1	177.0-187.0
Acetyl value	141.3-154.8	143.0-150.0
Iodine number	80.0- 85.9	82.0-90.0

* One sample had only 34.63% oil but this is beyond the usual limits and is not included here.