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A SIMPLE METHOD FOR DETERMINING THE OIL CONTENT OF SEEDS AND OTHER OIL-BEARING MATERIALS

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INTRODUCTION

Industrial enterprises are constantly in search of methods of analysis which will shorten their laboratory work and give more efficient plant control. Typical of such methods are those now in use by the steel chemist to determine carbon and phosphorous, by the sugar chemist to ascertain the sugar content of sirups, etc., and by the cereal chemist to find the percentage of moisture in wheat and flour. The vegetable-oil industry needed a simple and accurate test, adapted to the analysis of a large variety of oil-bearing commodities. It is desirable that the buyer of oil-bearing materials should know, in a short time, the oil content of his raw materials, and plant operation should be more efficiently maintained by frequent check tests made while the plant is in operation.

Vegetable-oil chemists have made many attempts to simplify the ether-extraction method for making accurate oil determinations and to develop some rapid method which would give results sufficiently accurate for routine use in testing raw and finished products. As a practical matter, few of these proposed rapid methods of analyzing the fat or oil content of seeds have proven to be worth while. The time element has not been sufficiently reduced, or the expense of making the test is too great, or the accuracy (as compared with standard methods of analysis) is not sufficient, or the method is not simple enough for the average person to carry out.

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WESSON'S TEST (OPTICAL METHOD)

Early in 1920, Wesson [1] proposed an optical method whereby the oil content of cottonseed meal and cottonseed meats could be measured by noting the change in the refractive index of the fat or oil solvent as it became diluted with the cottonseed oil extracted from the sample under the conditions for his test.

Fundamental to the success of Wesson's test was the choice of a suitable solvent. It must be a solvent which (1) would have an index of refraction that differed widely from that of the vegetable oils, (2) would be nonvolatile during the period of the test, (3) would have a low coefficient of expansion, and (4) would be inexpensive and noninflammable. These characteristics were found in a substance known to the trade as halowax, grade No. 1000 or grade No. 1007. This substance, which is an impure substituted monochlornaphthalene, has a specific gravity at 25° C. of approximately 1.25; it boils at 350° ; it has a low coefficient of expansion; it is noninflammable. Its refractive index is approximately 1.63500 at 25° which is considerably higher than the refractive indices which are usually associated with the vegetable oils. The refractive indices of some vegetable oils at 25° are as follows: Cottonseed oil, 1.47162; linseed oil, 1.48059; mustard oil, 1.47533; peanut oil, 1.47329; sesame oil, 1.47214; and soy-bean oil, 1.47367. Cacao butter has a refractive index of 1.44960 at 40°.

As a further requirement for making the optical method practicable it was found necessary to have a refractometer which could be easily read to five decimal places. This was forthcoming in an American-made instrument of recent manufacture, which is illustrated in Figure 1.

Briefly, Wesson's method consists of treating a weighed quantity of ground cottonseed meal, or cottonseed meats, with a definite quantity of the solvent for such period of time as will allow the solvent to dissolve the vegetable oil from the ground material. A portion of this uniform mixture of halowax and vegetable oil is then removed from the ground material by filtration and its refractive index is noted. The refractive-index reading of the mixture is then compared with readings in standard tables. Such tables are prepared from a knowledge of what the refractive-index readings would be if known percentages of the oil under test were mixed with known quantities of halowax.

Working with cottonseed meal, a material of low oil content, Wesson obtained a result which made his method compare very favorably with the usual ether-extraction method. When cottonseed meats, a material of high oil content, were used, the comparison was not so favorable. Nevertheless, the apparent simplicity of the method, coupled with the speed with which a test could be completed, warranted a comprehensive study of this method to see what modifications of the technic were necessary to make the test applicable to all types of oil-bearing materials.

MODIFICATION OF THE TECHNIC OF THE WESSON TEST

The Wesson method was studied in all its details in the grain research laboratory of the Bureau of Agricultural Economics and,

[1] WESSON, D. NEW OPTICAL METHOD FOR DETERMINING OIL IN OIL-MILL MATERIALS. Cotton Oil Press 4 (3) : 70-73. 1920.

as a result, the application of this method to the analysis of flaxseed and linseed meal was accomplished. The results were reported in Department Bulletin 1471.[2]

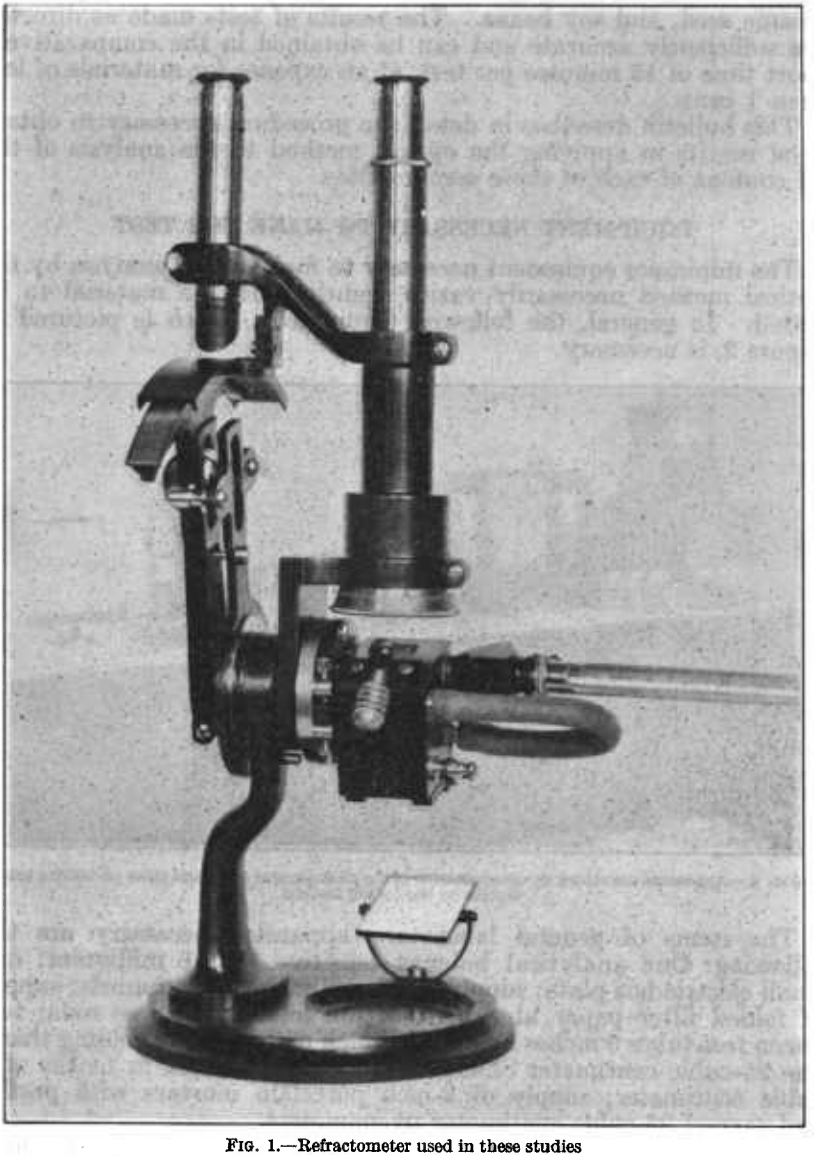

FIG. 1.—Refractometer used in these studies

Since the publication of that bulletin, many requests that the optical method be adapted to other oil-bearing materials have been received by the grain-research laboratory. In answer to these requests, investigations and experiments have now been completed

[2] COLEMAN, D. A., and FELLOWS, H. C. OIL CONTENT OF FLAXSEED, WITH COMPARISONS OF TESTS FOR DETERMINING OIL CONTENT. U. S. Dept. Agr. Bul. 1471, 35 p., illus. 1927.

through which this test has been adapted to the following additional commodities: Cacao beans, cacao meats, cacao hulls, chocolate-chip liquor, bittersweet chocolate, cocoa, cottonseed and cottonseed meats, cottonseed meal, flaxseed, linseed meal, mustard seed, peanuts, sesame seed, and soy beans. The results of tests made as directed are sufficiently accurate and can be obtained in the comparatively short time of 15 minutes per test, at an expense for materials of less than 1 cent.

This bulletin describes in detail the procedure necessary to obtain good results in applying the optical method to the analysis of the oil content of each of these commodities.

EQUIPMENT NECESSARY TO MAKE THE TEST

The minimum equipment necessary to make an oil analysis by the optical method necessarily varies slightly with the material to be tested. In general, the following equipment, which is pictured in Figure 2, is necessary.

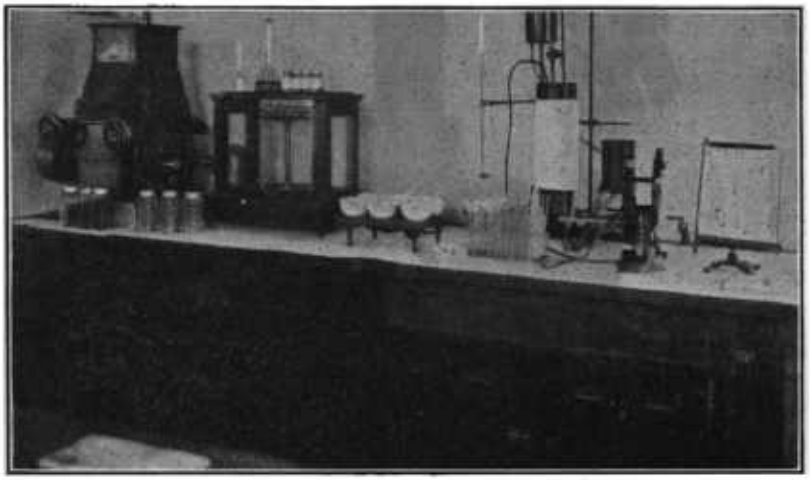

FIG. 2.—Apparatus assembled for determination of the oil content of seeds and other oil-bearing substances by the optical method

The items of general laboratory apparatus necessary are the following: One analytical balance sensitive to 0.1 milligram; one small electric hot plate; supply of 40-millimeter glass funnels; supply of folded filter paper, absorbent cotton and small glass rods; two dozen test tubes 5 inches by one-half inch with rack for holding them; one 25-cubic centimeter Shellbach burette graduated in tenths of a cubic centimeter; supply of 3-inch porcelain mortars with pestle; and several 25-cubic centimeter pycnometers.

Suitable grinding equipment is essential. To test materials of a low to medium oil content, the ordinary coffee or attrition mill will suffice. To test materials of a high oil content, it is sometimes necessary to use a small flouring mill, with 6 by 6 inch corrugated rolls running at a differential of 1½ to 1. These rolls should be corrugated 40 to the inch. For materials like cacao meats and chocolate-chip liquor, a small chocolate grater is necessary. In this bulletin, the best device to use, in order that the material be placed in the

best possible condition for testing, will be named, in each case, in the section on the preparation of the sample of that material.

The items of special laboratory equipment needed, are as follows: Grinding equipment as described above; one water-jacketed five-place refractometer, calibrated to four decimal places over the interval from 1.3 to 1.7; and one temperature-regulating device. An efficient way to set up the refractometer and temperature-regulating device is shown in Figure 3.

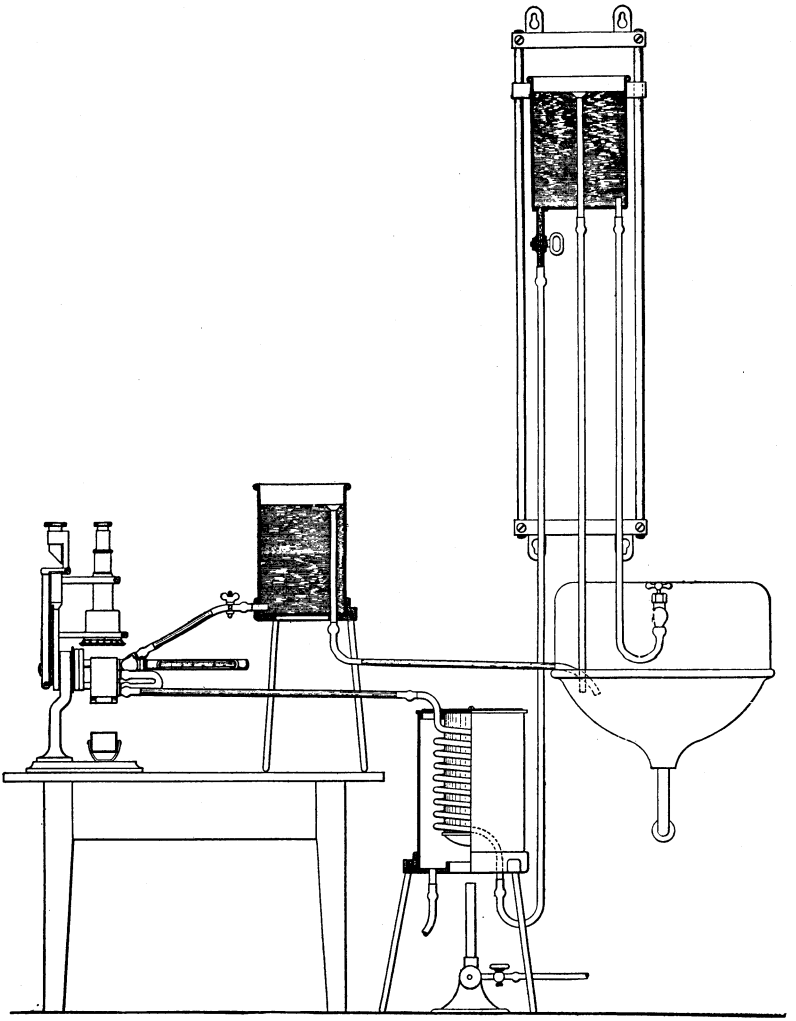

FIG. 3.—A convenient way to attach the temperature-regulating device to the refractometer

HOW TO MAKE AN OIL TEST BY THE OPTICAL METHOD

The composition of the material to be analyzed determines the manner in which it is to be prepared for analysis. Material which is rich in oil must be treated differently from material which has low oil content.

PREPARING THE MATERIAL FOR ANALYSIS

The directions given below should be followed strictly if success is to be obtained in making an oil analysis by the optical method. Each commodity has been placed in a group according to the method of preparation best adapted to it.

CACAO BEANS, RAW OR ROASTED,[3] COTTONSEED MEATS,[3] MUSTARD SEED, PEANUTS,[3] AND SOY BEANS

Grind 75 to 100 grams of the material in a coffee mill which is provided with adjustments for increasing the fineness of division. Pass the material first through coarsely adjusted burrs and then regrind to as fine a condition as possible.

CACAO MEATS

Grind 75 to 100 grams of the material in a coffee mill in which the burrs are coarsely adjusted. Melt the coarsely ground material at low heat on a hot plate and pour into a mold. Chill in an ice box. Grate the molded cake by means of chocolate grater. Melt, chill, and grate again.

CHOCOLATE-CHIP LIQUOR AND BITTER-SWEET CHOCOLATE

Grate the material with a chocolate grater. Melt, chill, and grate twice in order to secure a uniform sample.

CACAO SHELLS, COTTONSEED MEAL, AND LINSEED MEAL

Grind 75 to 100 grams of the material in a coffee mill to a fineness that will allow 80 per cent of it to pass through a 34-grits-gauze sieve.

COCOA

Cocoa usually does not need further grinding. If it does, pass 75 to 100 grams through a coffee mill which is adjusted to do finest grinding.

FLAXSEED OR LINSEED, AND SESAME SEED

Pass 75 to 100 grams of the seed through a small-sized flouring mill, pouring the seed into the mill in small quantities so that the roll will not jam and flatten out the resulting meal. A mill which has 6 by 6 inches corrugated rolls which rotate at a differential of 1½ to 1 has proved satisfactory. The rolls should be corrugated at least 40 to the inch.

COTTONSEED

Remove linters by immersing in concentrated sulphuric acid for three to five minutes. Wash the delinted seed free from acid with tap water. Rapidly remove excess water and allow seed to become air dry. (A small fan is helpful.) Proceed with the grinding as directed under cacao beans.

EXTRACTING THE VEGETABLE OIL

The procedure for extracting the vegetable oil from the commodities mentioned is as follows:

Weigh out 2 grams of the prepared material into a 3-inch porcelain mortar which has been previously heated to approximately 70° C.;

[3] The formation of a paste should be avoided when grinding these materials.

add 4 cubic centimeters of halowax and 1 to 2 grams of fine sea sand[4] (90 mesh) and rub the material, sand, and halowax together with a pestle for at least two minutes. The addition of the sand hastens the extraction by breaking open the oil cells in the cacao beans and at the same time aids in further pulverizing the cacao beans.

Filter through a small folded filter paper (9 centimeters) and catch the filtrate in a small test tube.

READING THE REFRACTIVE INDICES

After the test tube and contents have cooled to room temperature, place a drop of the filtrate on the lower prism of the refractometer and determine its refractive index, noting at the same time the temperature at which the readings are made. This is necessary, because, as is usual with optical measurements, refractometer readings are subject to changes in temperature.

It is necessary, therefore, that refractometer readings be corrected for temperature changes and that the results be finally expressed as readings at a definitely stated temperature. In order that results may be generally comparable it is suggested that all results be reduced to a uniform temperature basis. For this purpose an average laboratory temperature of 25° C. has been assumed, to which all readings in this bulletin have been corrected.

The influence of temperature changes on the refractometer reading for the commodities and concentrations covered in this bulletin was found to be constant over a rather wide range of temperatures at 0.00045 for each degree centigrade. Correction for temperature is made by multiplying the difference between the reading temperature and 25° C. by the constant factor 0.00045, adding the result to the refractometer reading when it is made at temperatures higher than 25° C. and subtracting the result when the reading is made at temperatures lower than 25° C.

Inasmuch as changes of temperature in the laboratory, as well as mechanical disturbances attendant upon the use of the refractometer, will cause the refractometer to get out of adjustment, frequent use of the test slab (supplied with the refractometer) should be made in order that the refractometer may be kept always in adjustment.

After the refractometer readings have been made, the prisms should be wiped with soft cotton to remove all traces of halowax. Long exposure to the action of this solvent will dissolve the cement in which the prisms are set.

After the corrected refractive-index reading of the test mixture at 25° C. has been determined, the next step is to compare this reading with readings in a conversion table previously prepared from a determination of the refractive-index readings at 25° C. of weighed mixtures of the vegetable oil under study and halowax.

HOW TO PREPARE A STANDARD CONVERSION TABLE

The preparation of the conversion table is the same for all commodities. It is prepared as follows:

(1) In several previously weighed 4-ounce bottles place approximately 25 cubic centimeters of halowax, weigh again, and record the

[4] The addition of sand in the extraction of cocoa, cottonseed, cottonseed meal, cottonseed meats, mustard seed, and soy beans may be dispensed with if proper fineness of division is assured.

weight of the halowax added to each bottle. Three or four bottles will usually suffice.

Next add enough of the oil [5] (cottonseed, linseed, peanut, cacao butter, etc.) for which the conversion table is being made, to each of the several bottles so that, by weight, definite percentages of the oil in the halowax-oil mixture will be obtained. It is not necessary to obtain even percentages, as fractional percentages will do for the purpose at hand.

For conversion charts in which the percentage of oil in the commodity will vary from 30 to 45 per cent, mixtures should be made containing approximately 10, 12, and 14 per cent of the oil to be tested. Mixtures should contain more oil than this when the percentage of oil in the material to be tested varies from 45 to 60 per cent, and less if conversion tables are to be made for samples that have low oil content. This is because the change in the index of refraction for each per cent of oil in the mixture is different in the low, medium, and high portions of the oil-content percentage scale.

When the weighed vegetable oil and halowax mixtures have been thoroughly mixed, read the refractive index of each mixture, and read the refractive index of the halowax, without the addition of the vegetable oil, corrected to a temperature of 25° C., and from these data determine the change in the refractive index for each 1 per cent of vegetable oil present in the mixture. Table 1 illustrates this procedure.

TABLE 1.—*Determination of the rate of change in the refractive index of halowax caused by known percentages of cacao butter*

[All readings made at or corrected to 25° C.]

Percentage of cacao butter in mixture with halowax	Refractive index of mixture of halowax [1] and cacao butter	Change in refractive index of halowax due to cacao butter present	Difference in refractive index per 1 per cent of cacao butter
14.305	1.60237	0.03117	0.002179
14.772	1.60135	.03219	.002179
15.611	1.59957	.03397	.002176
15.910	1.59885	.03469	.002180
16.134	1.59832	.03522	.002183
16.848	1.59689	.03665	.002175

[1] Refractive index of halowax 1.63354.

Average, 0.002179.

(2) It will be seen from the results given in Table 1 that when a vegetable oil, such as cacao butter, is mixed with halowax a change takes place in the original refractive index of the halowax. It will also be seen that over a relatively large range, the change in the refractive index of the halowax is constant for each per cent of cacao butter present in the mixture. In the example given, 1 per cent of cacao butter changed the original refractive index of the halowax 0.002179, or 217.9 points.

(3) In perfecting the technic for making the oil test it was found that the addition of 4 cubic centimeters of the solvent, halowax, to

[5] Inasmuch as the optical method is standardized against the ether-extraction method, oil extracted with petroleum ether should be used.

2 grams of the ground material provided ideal extraction conditions; that is, with these quantities of materials all the vegetable oil was extracted by the halowax and a sufficient quantity of the extract could be separated by filtration for use with the refractometer. However, inasmuch as the halowax is added by volume, and the ground material on which the extraction is to be made is added in grams, and the results are expressed in percentage by weight, it is necessary to determine the weight of 4 cubic centimeters of halowax. This is accomplished by the direct weighing of several 4-cubic centimeter portions of halowax or by determining the specific gravity of halowax and multiplying this value by 4.

(4) The preparation of the conversion table from here on, therefore resolves itself (1) into determining theoretically what the actual percentage of vegetable oil would be in the halowax mixture, when ground materials that have different oil contents are mixed together under the conditions outlined in paragraph (3) above, (2 grams of material and 4 cubic centimeters of halowax); (2) into determining how much such percentages of vegetable oil would change the refractive index of the halowax; and (3) into calculating the actual conversion values by subtracting the values obtained in item 2 of this paragraph from the refractive index of the halowax, in order to obtain the actual refractometer readings for samples of the material containing different percentages of oil.

To illustrate: Suppose a sample of material contained 45 per cent of oil. A 2-gram sample would contain 0.9 of a gram of oil. If this quantity of oil were present with 4 cubic centimeters of halowax, (which for the purpose of this illustration weighs 4.904 grams), the percentage of oil present would be found by dividing the weight of the vegetable oil present by the sum of the weights of the halowax and the vegetable oil and pointing off two decimal places to the right. The formula follows:

$$\frac{\text{Weight of oil in 2-gram sample of commodity} \times 100}{\text{Weight of 4 cubic centimeters of halowax oil plus weight of oil in 2-gram sample of commodity}} = \text{Percentage of vegetable oil in the mixture.}$$

Table 2 perhaps brings this out more clearly, as it shows the percentage of cacao butter in a mixture of halowax and cacao butter, made by adding 4 cubic centimeters of halowax (weighing 4.904 grams) to each of four 2-gram samples of ground cacao beans containing, respectively, 45, 45.1, 45.3, 45.7 and 46 per cent of cacao butter.

The change that such percentages of oil will make on the refractive index of the halowax is ascertained by multiplying the percentage of oil in the mixture of halowax and vegetable oil by the change that 1 per cent of the vegetable oil will make on the refractive index of the halowax. Thus, again referring to Table 2, a sample of ground cacao beans that contains 45 per cent of cacao butter would have 15.504 per cent of cacao butter in the mixture with halowax under the conditions laid down in paragraph (3) (page 8). The addition of 15.504 per cent of cacao butter would change the refractive index of the halowax 15.504 times 0.002179, or 0.03378. (See Table 1.)

Finally the values found (as directed in paragraph 4, items 1 and 2) are subtracted from the original refractive index of the halowax. From these data the conversion table is completed. It will be similar to the one illustrated in Table 3.

The refractive index of halowax is not constant throughout various lots. It is necessary, therefore, to prepare for each new lot of the solvent, a standard conversion table for each kind of oil-bearing material on which the test is to be made. It is recommended that a quantity of halowax sufficient to last over an extended period be purchased so that one standard chart or table can be used for a long time.

TABLE 2.—*Percentage of oil in a mixture of halowax and cacao butter made by adding 4 cubic centimeters of halowax oil (4.904 grams) to 2-gram samples of ground cacao beans containing, respectively, 45, 45.1, 45.3, 45.7 and 46 per cent of cacao butter*

Percentage of cacao butter in cacao-bean sample	Percentage of cacao butter in the mixture of halowax-cacao butter	Percentage of cacao butter in cacao-bean sample	Percentage of cacao butter in mixture of halowax-cacao butter
45.0	15.504	45.7	15.707
45.1	15.533	46.0	15.794
45.3	15.591		

TABLE 3.—*Sample conversion table; Percentages of oil (or cacao butter) in samples of cacao beans, as indicated by refractometer readings obtained in testing as directed*

Refractometer reading	Per cent cacao butter	Refractometer reading	Per cent cacao butter	Refractometer reading	Per cent cacao butter	Refractometer reading	Per cent cacao butter
1.60298	40.0	1.60039	44.0	1.59786	48.0	1.59542	52.0
1.60291	40.1	1.60033	44.1	1.59780	48.1	1.59536	52.1
1.60285	40.2	1.60027	44.2	1.59774	48.2	1.59530	52.2
1.60278	40.3	1.60021	44.3	1.59767	48.3	1.59524	52.3
1.60271	40.4	1.60014	44.4	1.59761	48.4	1.59518	52.4
1.60265	40.5	1.60007	44.5	1.59755	48.5	1.59512	52.5
1.60259	40.6	1.60001	44.6	1.59749	48.6	1.59506	52.6
1.60252	40.7	1.59995	44.7	1.59742	48.7	1.59500	52.7
1.60246	40.8	1.59988	44.8	1.59736	48.8	1.59494	52.8
1.60239	40.9	1.59982	44.9	1.59730	48.9	1.59488	52.9
1.60232	41.0	1.59976	45.0	1.59724	49.0	1.59482	53.0
1.60226	41.1	1.59969	45.1	1.59718	49.1	1.59476	53.1
1.60219	41.2	1.59963	45.2	1.59711	49.2	1.59470	53.2
1.60213	41.3	1.59956	45.3	1.59705	49.3	1.59464	53.3
1.60206	41.4	1.59950	45.4	1.59699	49.4	1.59458	53.4
1.60200	41.5	1.59944	45.5	1.59693	49.5	1.59452	53.5
1.60193	41.6	1.59937	45.6	1.59687	49.6	1.59446	53.6
1.60187	41.7	1.59931	45.7	1.59681	49.7	1.59440	53.7
1.60180	41.8	1.59924	45.8	1.59674	49.8	1.59434	53.8
1.60174	41.9	1.59918	45.9	1.59668	49.9	1.59428	53.9
1.60167	42.0	1.59912	46.0	1.59662	50.0	1.59422	54.0
1.60160	42.1	1.59906	46.1	1.59656	50.1	1.59416	54.1
1.60154	42.2	1.59960	46.2	1.59651	50.2	1.59410	54.2
1.60147	42.3	1.59893	46.3	1.59645	50.3	1.59404	54.3
1.60141	42.4	1.59887	46.4	1.59639	50.4	1.59398	54.4
1.60135	42.5	1.59881	46.5	1.59633	50.5	1.59392	54.5
1.60129	42.6	1.59875	46.6	1.59627	50.6	1.59386	54.6
1.60122	42.7	1.59869	46.7	1.59621	50.7	1.59380	54.7
1.60116	42.8	1.59862	46.8	1.59615	50.8	1.59374	54.8
1.60109	42.9	1.59856	46.9	1.59609	50.9	1.59368	54.9
1.60103	43.0	1.59850	47.0	1.59603	51.0	1.59362	55.0
1.60097	43.1	1.59844	47.1	1.59597	51.1	1.59356	55.1
1.60090	43.2	1.59837	47.2	1.59591	51.2	1.59351	55.2
1.60084	43.3	1.59831	47.3	1.59584	51.3	1.59345	55.3
1.60077	43.4	1.59824	47.4	1.59578	51.4	1.59333	55.4
1.60071	43.5	1.59818	47.5	1.59572	51.5	1.59327	55.6
1.60064	43.6	1.59811	47.6	1.59566	51.6	1.59321	55.7
1.60058	43.7	1.59805	47.7	1.59560	51.7	1.59315	55.8
1.60051	43.8	1.59798	47.8	1.59554	51.8	1.59309	55.9
1.60045	43.9	1.59792	47.9	1.59548	51.9	1.59303	56.0

COMPARISON OF RESULTS OF THE ETHER-EXTRACTION AND THE OPTICAL METHODS

The results which can be obtained by the optical method compare very favorably with the results obtained from the same samples by the standard extraction method in which petroleum ether is used as the solvent. (See Table 4.) In obtaining the results by the optical method the directions given in the foregoing pages were used. For the comparative test, a 2-gram portion of the ground material was reground in a mortar with fine sand, and the entire mass was removed to a fat-free thimble. This thimble, in turn, was seated in a Gooch crucible made of medium-mesh alundum. The mortar was thoroughly rinsed with petroleum ether, the rinsings being transferred to the fat-free thimble containing the material for extraction. Extraction was accomplished with a Bailey-Walker apparatus,[6] the extraction being continued for a period of 24 hours.

Results of 10 typical tests on each commodity studied are given in Table 4. In only 3 of 70 instances was the difference between the two methods greater than 0.25 per cent. In some instances the results obtained by the two tests were identical.

Commodities that have about 3 to 8 per cent of oil are more difficult to analyze by the optical method than are commodities that have a higher percentage of oil, because the small quantity of oil present in 2 grams of ground material does not change the refractive index of the solvent (halowax) to as great an extent as would the oil from a sample of the same size, of a commodity that has a higher oil content. The smaller the change in the refractive index, the greater the difficulty in making accurate readings.

TABLE 4.—*Accuracy of the optical method for testing oil content of materials: Results obtained by the optical method as compared with results obtained by the standard ether-extraction method*

Commodity	Oil content as determined by the ether-extraction method	Oil content as shown by the optical method	Difference [a]	Commodity	Oil content as determined by the ether-extraction method	Oil content as shown by the optical method	Difference [a]
Cacao beans, raw:	*Per cent*	*Per cent*	*Per cent*	Cocoa:	*Per cent*	*Per cent*	*Per cent*
Sample 1	46.21	46.33	+0.12	Sample 1	24.86	24.83	−.03
Sample 2	46.15	46.14	−.01	Sample 2	17.64	17.47	−.17
Sample 3	46.44	46.22	−.22	Sample 3	24.82	24.83	+.01
Cacao beans, roasted:				Sample 4	25.49	25.38	−.11
Sample 1	45.27	45.31	+.04	Chocolate, bitter sweet:			
Sample 2	48.01	48.04	+.03	Sample 1	40.00	40.05	+.05
Sample 3	48.39	48.09	−.30	Chocolate, chip liquor:			
Cacao meats: [b]				Sample 1	34.16	34.20	+.04
Sample 1	54.15	54.28	+.13	Cottonseed:			
Sample 2	52.93	53.06	−.13	Sample 1	21.18	21.08	−.10
Sample 3	56.03	56.06	+.03	Sample 2	20.72	20.80	+.08
Sample 4	54.30	54.36	+.06	Sample 3	24.76	24.75	−.01
Cacao shells:				Sample 4	19.72	19.71	−.01
Sample 1	18.90	18.74	−.16	Sample 5	23.65	23.56	−.09

[a] Plus sign indicates a percentage greater than that obtained by the ether-extraction method. Minus sign indicates a lesser percentage.
[b] Eyes and shells removed.

[6] WALKER, P. H., and BAILEY, L. H. A SIMPLE EXTRACTION APPARATUS. Jour. Indus. and Engin. Chem. 6:497–499, illus. 1914.

TABLE 4.—*Accuracy of the optical method for testing oil content of materials: Results obtained by the optical method as compared with results obtained by the standard ether-extraction method*—Continued

Commodity	Oil content as determined by the ether-extraction method	Oil content as shown by the optical method	Difference [a]	Commodity	Oil content as determined by the ether-extraction method	Oil content as shown by the optical method	Difference [a]
Cottonseed—Continued.	*Per cent*	*Per cent*	*Per cent*	Linseed meal—Contd.	*Per cent*	*Per cent*	*Per cent*
Sample 6	23.94	23.78	−.16	Sample 4	5.82	5.41	−.41
Sample 7	22.37	22.23	−.14	Sample 5	4.57	4.80	+.23
Sample 8	23.52	23.40	−.12	Sample 6	8.11	8.28	+.17
Sample 9	23.57	23.63	+.06	Sample 7	7.40	7.32	−.08
Sample 10	22.55	22.28	−.27	Sample 8	6.04	6.12	+.08
Cottonseed meal:				Sample 9	7.93	7.70	−.23
Sample 1	7.79	7.51	−.28	Sample 10	6.13	5.97	−.16
Sample 2	5.10	5.04	−.06	Mustard screenings:			
Sample 3	6.33	6.50	+.17	Sample 1	25.48	25.38	−.10
Sample 4	7.00	6.85	−.15	Sample 2	26.34	26.42	+.08
Sample 5	7.36	7.36	.00	Sample 3	19.84	19.79	−.05
Sample 6	5.52	5.53	+.01	Sample 4	15.28	15.17	−.11
Sample 7	8.01	7.89	−.12	Sample 5	40.48	40.38	−.10
Sample 8	4.78	4.81	+.03	Sample 6	22.25	22.47	+.22
Sample 9	5.00	5.02	+.02	Sample 7	30.74	30.67	−.07
Sample 10	6.44	6.37	−.07	Sample 8	23.65	23.55	−.10
Cottonseed meats:				Sample 9	22.60	22.51	−.09
Sample 1	34.31	34.22	−0.09	Sample 10	28.35	28.16	−.19
Sample 2	34.16	34.21	+.05	Peanuts:			
Sample 3	34.31	34.29	−.02	Sample 1	47.26	47.29	+.03
Sample 4	34.41	34.28	−.13	Sample 2	48.56	48.56	.00
Sample 5	34.31	34.30	−.01	Sample 3	47.47	47.36	−.11
Sample 6	34.32	34.31	−.01	Sample 4	39.23	39.33	+.10
Sample 7	29.30	29.26	−.04	Sample 5	51.07	51.18	+.11
Sample 8	32.60	32.55	−.05	Sample 6	49.32	49.30	−.02
Sample 9	29.13	29.21	+.08	Sample 7	51.32	51.38	+.06
Sample 10	31.70	31.60	−.10	Sample 8	49.10	49.27	+.17
Flaxseed, linseed:				Sample 9	48.43	48.34	−.09
Sample 1	41.10	40.87	−.23	Sample 10	49.51	49.60	+.09
Sample 2	37.34	37.22	−.12	Sesame:			
Sample 3	35.28	35.55	+.27	Sample 1	44.92	44.79	−.13
Sample 4	39.24	39.32	+.08	Soy beans:			
Sample 5	43.55	43.56	+.01	Sample 1	14.68	14.83	+.15
Sample 6	37.30	37.20	−.10	Sample 2	18.56	18.43	−.13
Sample 7	38.64	38.56	−.08	Sample 3	13.38	13.56	+.18
Sample 8	40.53	40.33	−.20	Sample 4	17.87	17.96	+.09
Sample 9	36.64	36.66	+.02	Sample 5	18.11	18.11	.00
Sample 10	35.95	36.08	+.13	Sample 6	19.55	19.83	+.28
Linseed meal:				Sample 7	19.37	19.46	+.09
Sample 1	6.34	6.39	+.05	Sample 8	18.63	18.70	+.07
Sample 2	6.34	6.13	−.21	Sample 9	19.23	19.38	+.15
Sample 3	5.65	5.50	−.15	Sample 10	20.41	20.40	−.01

[a] See footnote on p. 11.

ADAPTATION OF THE METHOD TO PLANT BREEDING

In breeding experiments with oil-bearing plants, it is desirable to know the oil or fat content of the various progeny at an early date. If the oil or fat content is known early, experiments may sometimes be shortened by one or two seasons.

In the past it has been difficult to secure such information early in the breeding experiment as the quantity of seed at hand has not usually been sufficient to allow the grinding necessary when the ether-extraction method is used. With the optical method, however, the desired information may be obtained at an early stage, as tests may be made with very small quantities of the material to be tested. Samples as small as one-half gram may be tested with satisfactory results.

The technic of testing a small sample is not materially different from that described above. The test is carried out as follows.:

Weigh the material to be tested, unground, into a mortar which has previously been heated, using even quarter-grams; that is, a sample of 0.5, 0.75, 1, or 1.25 grams of material. Add the halowax, using the same proportion of the standard 4-cubic centimeter quantity as the sample is of the standard 2-gram sample, or 0.5 cubic centimeter of halowax for each 0.25 gram of material. Then add a convenient quantity of fine sea sand (1 gram) and, with a pestle, reduce the material to a fine state of subdivision. Filter, and determine the percentage of oil as previously directed. If a conversion table for the kind of material tested and the lot of halowax used is available a new table for the experimental material need not be made.

SUMMARY

In the search for a rapid, safe, and accurate test for the oil content of seeds and other oil-bearing materials for general use, the optical method applied to cottonseed products by Wesson was found most promising. The procedure necessary in the application of the optical method to a number of commodities was worked out in the grain-research laboratory of the Bureau of Agricultural Economics, and a standard practice for each is recommended. By this method determinations can be made in 15 minutes, at a cost for materials of less than 1 cent per test, which agree very closely with those obtained by the standard ether-extraction method.

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