U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF CHEMISTRY—BULLETIN NO. 77.
H. W. WILEY, Chief of Bureau.

OLIVE OIL AND ITS SUBSTITUTES.

BY

L. M. TOLMAN and L. S. MUNSON.

Prepared under the direction of
W. D. BIGELOW,
Chief of Food Laboratory.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., July 3, 1903.

Sir: I have the honor to transmit herewith for your inspection and approval a manuscript relating to olive oils and their adulterations, and embodying the investigations made in this Bureau of American and imported pure olive oils and adulterations thereof. This work was done under the act of Congress authorizing the Secretary of Agriculture "to investigate the adulteration of foods, drugs, and liquors," and I recommend that the results as reported herein be published as Bulletin No. 77 of the Bureau of Chemistry.

Respectfully,

H. W. Wiley,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

INTRODUCTION.

The work reported in this bulletin was begun on imported oils received through the customs officers, with a view to determining the nature of the products brought into the United States from abroad and sold as olive oil. It was then thought advisable to go into the open market and secure oils sold in retail stores under foreign labels in order to make a comparison of olive oil as it is received by the customs officers and as it is sold to the consumer. Having thus collected considerable data on oils of other countries, it seemed expedient to make a study of American olive oils for the sake of comparison. Many samples were therefore purchased in the open market, and a number of representative manufacturers were requested to furnish samples of their product as it left the mill. These requests were quite generally complied with, and in each case the manufacturer sent with his sample an affidavit as to its purity. Employees of the Bureau visited New York, Philadelphia, Washington, Boston, New Haven, Rochester, Buffalo, Burlington, Vt., New Orleans, Chicago, St. Louis, and San Francisco, and purchased both American and foreign oils found in as many stores, selected at random, as it seemed advisable to visit.

The relatively low price at which imported oils are sold as compared with California oils may often be attributed to their inferior quality. In selecting material for the work reported in this bulletin no samples were taken which were not sold as olive oil. Oils sold under other names, or simply as salad oil, were not included. It is a matter especially worthy of comment that the California oils bought in the open market were all of superior quality, and that only two of the fifteen samples so obtained contained any oil other than olive oil. Of these two samples one was not labeled with the name of the manufacturer, but instead bore the name of the dealer.

Following the usual custom in such matters, all manufacturers resident in the United States were notified of the results of the examination previous to their publication, and no protests were received except those relating to the two oils mentioned. The dealer from whom one of these samples was obtained replied that he supposed that he was handling a high-grade article, while the manufacturers of the other sample wrote us that they had ceased to make olive oil because,

while making a high-grade article, they could not compete with inferior goods which were sold under the labels of first-class olive oil, and had decided to discontinue its manufacture. They stated that they employed no cotton-seed oil or other substitute at any time. Dealers whose names appeared on the labels as importers or manufacturers' agents were also notified.

For the lack of a better term, a number of salad oils are referred to in this bulletin as "olive oil substitutes." By this it is not intended to class them as inferior in any sense, or to disparage their legitimate use or their sale when labeled in such a way as to notify the purchaser of their nature. They are included in this bulletin, however, merely because, being cheaper oils, they are sometimes fraudulently substituted for olive oil and sold either at a price above their relative value, or at a price which brings olive oil into unfair competition. Such practices are fraudulent, and it is highly important for those engaged in the manufacture of olive oil, which has become an important industry in California, that they be forbidden.

Two Federal laws were passed by the last Congress which have a bearing on this subject. One of these (Public—No. 223) forbids the misbranding or false labeling of food products as to the place of their manufacture. The other (Public—No. 158) prohibits the importation into the United States of foods which are "found to be dangerous to health, or which are forbidden to be sold or restricted in sale in countries in which they are made or from which they are exported, or which shall be falsely labeled in any respect in regard to the place of manufacture or the contents of the package."

With these laws on the statute books it becomes important that purchasers should carefully read the labels on their purchases and note that the name of the manufacturer and the place of manufacture are distinctly stated. It is altogether probable that in the future oils distinctly labeled will be found to be as represented, as ordinarily fraudulent manufacturers will attempt to evade the law by omitting the place of manufacture rather than violate the law by making a false statement regarding it. As an illustration of this a label is reproduced (Pl. I, fig. 1) which was found on a bottle of maize oil purchased as olive oil. This label does not distinctly state that the bottle contains olive oil, but it is worded in such a way that it is only upon close examination that the purchaser will note the fact that the oil is represented not as "superior olive oil," but as "superior to any olive oil."

Among other instances of misbranded oil are a number which bear French or Italian labels and contain cotton-seed oil. As illustrations of this two labels are reproduced (Pl. I, fig. 2, and Pl. II, fig. 2) which are believed to have originated in this country.[a] The prevalence of the sale of cotton-seed oil under labels of this nature has led to frequent

[a] See page 56.

rumors that the cotton-seed oil exported from the United States is largely used as an adulterant or substitute for olive oil, and is sent back to us under another label and at greatly increased prices. It is difficult to understand how this idea could have gained credence. The shipment of the oil twice across the ocean would seem a needless expense. Oils of American origin are never subjected to a more rigid examination than imported oils. In view of these facts we would expect even foreign manufacturers to establish mixing and bottling establishments here, if they desire to handle American oil, and confine their importation to the labels.

In the following pages several instances of the presence of cheaper oils imported as olive oil are noted, but not a single instance has been found of the use of cotton-seed oil as an adulterant or substitute for olive oil in goods known to be imported,[a] although samples of imported olive oil were obtained from the customs officers of several of our leading ports, and every effort was made to secure a fair representation of the oils imported. We are therefore brought to the conclusion that cotton-seed oil is not imported under olive oil labels, as is frequently stated. Since the completion of our work on this subject this idea has been confirmed by a report from Consul-General R. P. Skinner, as a result of his investigation of the manufacture of olive oil in France. Mr. Skinner calls attention to the fact that edible olive oil to the value of $1,200,000 is brought annually into the United States, and that Marseilles alone has sometimes imported $3,000,000 worth of cotton oil in a single year. Mr. Skinner then says: "Therefore, if we also assume, a most improbable hypothesis, that these oils contain 25 per cent of cotton oil, we have accounted for cotton oil to the value of merely $300,000, a mere drop in the bucket as compared with the value of our cotton-oil exports." Another form of fraud is illustrated in Plate II, fig. 1, which is a reproduction of a label on a bottle received from the appraiser's stores imported as olive oil, but containing peanut oil.

I take this opportunity to express our indebtedness to all the American manufacturers who have cooperated in this work by furnishing the laboratory with samples of their oil, accompanied by affidavits as to their purity and descriptions of their methods of manufacture; and also to V. Villavecchia, custom-house chemist, Rome; Giacomo Dellepiane fu Andrea, Genoa; G. E. Colby and W. C. Blasdale, of the University of California, Berkeley, Cal., who have supplied samples of olive oil of known purity from different regions, and the V. D. Anderson Company, who prepared several samples of olive-oil substitutes for our laboratory.

W. D. BIGELOW,
Chief of Food Laboratory.

[a] Nine samples out of 250 recently received from the custom-house have contained cotton-seed oil.

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II. Fig. 1.—Label on olive oil mixed with peanut oil. Fig. 2.—Label on bottle of cottonseed oil 56

OLIVE OIL AND ITS SUBSTITUTES.

GENERAL DISCUSSION.

Statistics of the Olive Oil Trade.

Nearly the entire amount of olive oil used in this country comes from Italy, France, and California. The average annual total importation for the ten years next preceding 1901 was 803,716 gallons. Of this amount France sent us annually an average of 257,586 gallons and Italy 498,493 gallons. There are no means of ascertaining the amount produced in California, but it is probably a great deal less than the amount imported, as the California oil is scarcely known in the eastern markets, and is by no means the only oil offered on the western markets. Evidence of this is the fact that of 68 samples of commercial oils bought outside of California but two were California oils. On the other hand, of 29 samples of commercial oils bought in California 13 were produced in California, 4 were French oils, and 12 were Italian oils.

In 1897 Elwood Cooper[a] reported 2,500,000 olive trees in California capable of producing, besides dried and pickled olives, 2,000,000 gallons of oil. This amount, however, is greatly in excess of the present production, owing to the fact that, as shown later, both the French and Italian oils can be imported cheaper than the actual cost of production of the California product. The above figures are of interest in showing that California is capable of producing the entire amount of olive oil consumed in this country.

Table I.—*Importations and valuations of olive oil.*

Year.	Importations.				Valuation per gallon.			Total valuation of oils imported.
	From France.	From Italy.	From all other sources.	Total importations.	French oils.	Italian oils.	Average for all oils imported.	
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*				
1891	217,628	326,748	61,133	605,509	$1.59	$0.99	$1.21	$733,489
1892	222,534	431,322	52,630	706,486	1.72	.97	1.24	876,613
1893	261,332	379,150	46,370	686,852	1.69	1.01	1.29	891,424
1894	205,089	506,647	45,742	757,478	1.74	.97	1.20	909,897
1895	261,695	461,215	52,136	775,046	1.67	.96	1.22	952,405
1896	278,791	610,332	53,475	942,598	1.70	.92	1.17	1,107,049
1897	328,943	553,115	46,509	928,567	1.61	.98	1.22	1,134,077
1898	243,874	457,939	35,064	736,877	1.69	1.01	1.25	923,904
1899	280,515	609,038	40,489	930,042	1.64	.94	1.17	1,090,250
1900	275,461	649,423	42,818	967,702	1.65	1.00	1.21	1,170,871

[a] Address before the State Fruit Growers' Association of California.

Table I, prepared from the report of the Bureau of Statistics, Treasury Department, for 1900 (p. 289), gives the importations of edible olive oils, which pay a duty of 50 cents per gallon, and the valuation of these oils. According to this table the Italian oil is much cheaper than the French product, the average difference in price being about 60 cents per gallon. This difference is partly due to the packages in which the oils are shipped. The Italian oils are shipped largely in bulk or in tin cans, while the French oils are nearly always bottled and labeled in France. Of 27 samples of Italian oils furnished by the Treasury Department for examination, one was in bottle, one in tin, and the remainder in bulk. Of 27 samples of French oils from the same source, 17 were in labeled bottles and 10 were in bulk. Another reason for the lower average price of Italian oils is that a large amount of low-grade oil is imported. The price of the high-grade oils from both countries is about the same.

Table I shows that Italian oils are valued at about $1 per gallon and French oils at $1.60; adding 50 cents per gallon for duty to each of these would make their values $1.50 and $2.10, respectively. According to B. M. Lelong[a] the cost of production of California oil is $1.88 per gallon; adding to this 50 cents per gallon for bottling would make the actual cost of preparing the oils for market $2.38.

Table II gives the retail price per gallon of 83 samples of commercial oils, of which 67 are unadulterated and 16 adulterated. The figures on the unadulterated oils are in much the same ratio as the prices of the imported oils given in Table I and the actual cost of manufacture of the California oils as stated above.

TABLE II.—*Retail price per gallon of commercial samples.*

	Unadulterated oils.			Adulterated oils.		
	California.	French.	Italian.	California.	French.	Italian.
Number of samples	9	30	28	2	6	8
Average price per gallon	$5.87	$4.92	$4.20	$3.58	$4.03	$2.43
Maximum price per gallon	6.65	6.65	8.19	3.84	6.53	3.32
Minimum price per gallon	4.86	2.56	1.79	3.32	1.66	1.79

These figures show that California oils retail at a slightly higher price than French oils and French oils at a slightly higher figure than Italian oils. Referring to the price of adulterated oils, it will be seen that price is not always, or even generally, an indication of purity. The California oils show very little variation in price. This is due to the fact that all of the oil is of the highest quality. With both French and Italian oils some very low grades are placed on the market. The best grades of all three varieties of oil bring about the same price.

[a] Report of the Secretary of the California State Board of Agriculture, 1897.

Manufacture of Olive Oil.

The processes of manufacturing oil from the olive are very simple. The following general description is taken from a report to the governor of California by the State board of horticulture. The fruit is picked when ripe and dried either in the sun or by means of dryers. It is then crushed in a mill and the oil extracted by a powerful press, the details of these processes varying in different mills. In some places the olives are mixed with hot water before making even the first pressing. The first oil coming from the press is called the "virgin oil" and is the highest grade of salad oil. The pulp left from the first operation is subjected to a much higher pressure to produce the second-pressing oil. As a rule, this is mixed with the "virgin oil." The pulp is now treated with hot water and pressed again, when a third-grade oil is produced which is used for the table and also for lubricating fine machinery and for burning. The pulp still contains oily matter which is extracted with carbon disulphid, and used in making castile soap and in dyeing. In this country very little of this lower-grade product is made. The oil from the different pressings is run into tanks with water and allowed to stand until the pulp and gummy matters settle out. The oil is drawn off carefully, filtered, and stored in a cool, dark place until ready to be bottled, as olive oil becomes rancid very quickly if exposed to light and heat.

The following letters from California manufacturers of olive oil give in greater detail the processes used at the various mills:

Santa Clara, Cal., *May 7, 1902.*

My olives are picked when the average is ripe, but not *dead* ripe. They are spread on trays and allowed to evaporate a portion of the "water of vegetation" before pressing. They are crushed in an old-fashioned crusher, a revolving granite wheel worked by horsepower, and pressed in Italian oil sacks (bruscole), which are made of a kind of rush (guinco marino), which I import for the purpose. Practically all the work is done by "rule of thumb;" i. e., by careful study of the condition of the olives, etc. We try to keep the temperature of the pressing room at about 70° F., but the olives are not heated and come in cold. The run of a pressure is a mixture of water and oil, fine material of the olive, and oil. After the run has stood a short time the oil has in part come to the surface and the water sunk to the bottom with an intermediate stratum of a mixture of oil, water, and fine material. The oil is skimmed off the surface as soon as it appears in sufficient quantity, and this skimming is continued indefinitely until the oil is called for and filtered for bottling. The processes are the old ones in use in all the old countries where oil is expressed, and, so far as I can judge, the best known up to the present time. There is absolutely no secret. All depends on an intimate knowledge of the olive and these processes, and I employ selected Italians from the oil districts of Tuscany to secure efficient work. Frequent experiments are tried here in various lines, hoping to lessen the labor, but so far without any serious success. The De Laval Company tried a separator here this winter, and we hope that the expert, now fully acquainted with the difficulties to be met, may work out an oil separator or a series of separators which will take the olive just picked and give the refined oil at the end of the process or processes. An exceedingly able English mechanic has tried two experiments with a new press this

season here, and has since continued his experiments with olives sent to San Francisco, of which I have not as yet learned the result. I am confident that we shall before long have a machine which will avoid the costly process of partial evaporation and handle the olives as they come from the tree without sacks or the cider-press outfit, both of which mean much labor and expense.

Yours, very truly, EDWARD E. GOODRICH.

JAMACHA P. O., SAN DIEGO COUNTY, CAL., *March 30, 1902.*

Yours of March 22, asking for information in regard to olive oil, just received.

I have no secret process. I inclose a printed description of my process, which very clearly shows our method. We use no heat at any stage of the process. This cold-water separator I consider a great improvement over the old way of storing in large settling vats and skimming off the oil as it rises. By this process the oil is separated from the lees as fast as pressed. Every morning the oil expressed the day before is taken from the separator and placed in the racking tanks. I use only ripe olives and press them fresh from the tree. I put up two grades, only one of which we bottle. No. 2 is sold only in bulk to our local trade.

The cost of production of course depends entirely upon the price of olives. This season we have paid $40 per ton; this is $30 less than we have ever paid before. At this price for olives I figure my oil costs me very close to $1.50 per gallon for the season's run. Our olives in this locality are nearly all Mission. What few we have of others we mix with them.

Yours, very truly, C. M. GIFFORD.

C. M. GIFFORD'S PROCESS OF EXPRESSING OLIVE OIL.

My process of expressing olive oil is very simple and is as follows:

Only ripe olives are used. The fruit is first crushed in a large stone basin by means of a revolving stone wheel; it is then taken to the presses, where the oil and juice are separated from the pomace. The oil and juice are then passed through our new cold-water separator, where it comes in contact with a stream of pure spring water under heavy pressure, which thoroughly washes and removes from the oil all vegetable matter. Next it goes to the racking tanks, where it is thoroughly racked and allowed to clarify. It is now taken to the filter room and filtered through paper, made for this purpose, directly into the bottles.

The utmost care and cleanliness are absolutely necessary in the making of a high-grade olive oil, the product being very susceptible to taint.

SANTA BARBARA, CAL., *November 23, 1901.*

In my process the fruit is first dried in the sun for about two or three weeks, then crushed, pits and all, to a fine pulp, mixed with hot water (nearer 200° than 90° F., contrary to the accepted theory), and pressed through scalded Russia crash. This product is then stored for some months in heavy, *very clean* whisky barrels with the air entirely excluded, each barrel having considerable of the black, watery fluid, or lees, as it is called here, into which all impurities settle from the oil. If it shows signs of fermentation when first stored, which occurs some years, I place a glass siphon in the top of the barrel, cement in a cork with paraffin, and allow the gas to escape in pure water. The oil is then drawn off from a point just above the lees and filtered through paper, a sample of which is inclosed herewith. I never crushed the pits, but have made up my mind that the flavor of the oil is not changed at all by doing so. This oil brings the highest price of any oil I know of ($15 a case of 12 bottles, 6 to the gallon), and yet I am convinced it has always cost me that much

or more to produce it, although I charge up my fruit at 4 cents a pound, which is what we paid when we were running the El Montecito Manufacturing Company, but they are quoted now at just half ($40 a ton), which is just twice what I have to pay for picking (1 cent a pound). We have spent a small fortune, I think fully $50,000, in trying to introduce *pure olive oil*, and failed, closing the mill indefinitely. I think in our mill the oil cost us $1.17 a bottle, and much of it had to be sold at 40 cents.

Respectfully, yours, PEVERIL MEIGS.

METHODS OF ANALYSIS AND INTERPRETATION OF RESULTS.

The methods used in this work are not given in this bulletin if they are to be found in Bulletin 65[a] of this Bureau or are modifications of methods already published. More attention will be given to the discussion of the application of these methods and their limitations in the detection of various adulterants. In many control laboratories it is customary to make a few of the simpler determinations and qualitative tests, and to judge the state of purity of the oil from the results obtained by these determinations. While in many cases this is sufficient, especially if gross adulteration has been practiced, it is entirely inadequate in case the amount of foreign oil added is small. In such an instance a thorough examination is essential to properly judge an oil. The condition of an oil may frequently be such as to give abnormal values, even though it is absolutely pure. For example, an oil having a high acidity would give too low results for specific gravity, index of refraction, and possibly too low a Hübl value, especially if the free fatty acids had become oxidized. If the determination of acidity were made, it would explain at once the abnormal results. Frequently an oil that may be pronounced adulterated upon superficial examination will upon more careful analysis be found to be unadulterated.

The qualitative tests, while in many cases conclusive, must be used with caution. Halphen's test, if positive, is satisfactory proof of cotton-seed oil, but, as will be shown later, the heated oil does not respond with this reagent. The tests of Baudouin and of Villivecchia for sesame oil are conclusive if used with proper precautions, but some oils from Tunis give a color with this reagent that may easily be mistaken. The Bechi test for cotton-seed oil and the Renard test for peanut oil must be used with extreme care or misleading results will be obtained.

SPECIFIC GRAVITY.

The specific gravity was determined by the use of a hydrometer graduated from 0.9100 to 0.9300 at 15.5° C. and reading to 0.0002.

[a] Provisional methods for the analysis of foods, adopted by the Association of Official Agricultural Chemists, November 14, 15, 16, 1901.

The readings were made as near 15.5° C. as possible and correction for temperature made by the following formula:[a]

$$G = G' + 0.00063\ (T - 15.5°\ C.).$$

G = specific gravity at 15.5° C.
G′ = specific gravity at T.
0.00063 = mean correction for 1° C. (for olive oil).

The correction factors for other oils are given in the provisional methods for the analysis of foods.[b]

The determination of specific gravity is a quick way of detecting gross adulteration of olive oil with the seed oils, practically all of which have a higher specific gravity. The range of specific gravities on pure olive oils of the grade used for salad purposes is quite narrow. On 33 samples of pure California oils the specific gravity varied from 0.9162 to 0.9180, with an average of 0.9168. One sample, No. 673, had a specific gravity of 0.9149, but had 12.11 per cent of free acid, which explains the low gravity and excludes the oil from use for salad purposes. Eighteen samples of Italian oils gave a range of from 0.9155 to 0.9180, with an average of 0.9163. Blasdale[c] on 11 samples of California oils found a variation of from 0.9161 to 0.9174. Milliau[d] found on French oils a range of from 0.9169 to 0.9172, and for Tunis oils[e] a range of from 0.9170 to 0.9196, with an average on 49 samples of 0.9183. De Negri and Fabris[f] in a very exhaustive examination of Italian oils found on 70 samples a range of from 0.9160 to 0.9180, and an average of 0.9166. These authors found one sample of oil made from rotten olives which had a specific gravity of 0.9145. This low figure was most likely due to the presence of free fatty acids, which were not determined, but which were probably present in sufficient amounts to materially influence this constant and to exclude the product from edible oils. Colby[g] gives the range for California oils of 0.9140 to 0.9185, but in the absence of definite data regarding the amount of free acids present the lower limit can hardly be accepted for a normal oil. From the above figures it is apparent that there is but little variation in the specific gravity of edible olive oils from different sources and from different varieties of olives.

The specific gravity of California, French, and Italian olive oils varies from 0.9140 to 0.9185, while the oils from Algeria range as

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[a] Allen, Com. Org. Anal., 3d ed., vol. 2, pt. 1, p. 33. Winton, Connecticut Agr. Expt. Sta. Rept., 1900, pt. 2, p. 149.

[b] U. S. Dept. Agr., Bureau of Chemistry Bul. 65, p. 21.

[c] Jour. Amer. Chem. Soc., 1895, 17: 935.

[d] Bul. du Ministère de l'Agriculture, 1895, p. 139.

[e] Milliau, Bertainchand et Malet, Bul. de l'Agriculture et Commerce de Tunis, "Rapport sur les huiles d'olive de Tunisie, 1900."

[f] Annali del Lab. chim. centr. delle Gabelle, vol. 1, Gli Olii, pt. 1, p. 38.

[g] California Agr. Expt. Sta. Rept., 1897–98, p. 169.

high as 0.9196. Zammit[a] called attention to the fact that the presence of free acids in olive oils reduces the specific gravity, and the following table taken from his results shows the effect of excessive amounts:

TABLE III.—*Effect of excessive amounts of free acids in olive oils on their specific gravity.*

Free acid as oleic.	Specific gravity 15.5° C..	Free acid as oleic.	Specific gravity 15.5° C..
12 per cent	0.9147	25 per cent	0.9128
13 per cent	.9139	27 per cent	.9136
14 per cent	.9143	28 per cent	.9124
15 per cent	.9144	31 per cent	.9122
20 per cent	.9132		

Table IV gives the range of specific gravity of all the oils considered in this bulletin. Oils having an excessive amount of free acids, and consequently abnormal specific gravity, have been excluded from the ranges given in the column of "Results obtained in Bureau of Chemistry." This explains in many cases the lack of agreement between the results from the two sources. An example of this is one sample of peanut oil having 13.51 per cent of free acids and a specific gravity of 0.9155. The other three samples of peanut oil have specific gravities of 0.9186 and above, which are considered about normal for this oil.

TABLE IV.—*Specific gravity of oils.*

Kind of oil.	Results obtained in Bureau of Chemistry.	Compiled results.
California olive	0.9162 to 0.9180	0.9140 to 0.9185
Italian olive	.9155 to .9180	.9158 to .9180
French olive		.9169 to .9172
Algerian olive		.9170 to .9196
Lard	.9148 to .9175	.9150 to .9160
Rape	.9143 to .9163	.9112 to .9184
Mustard	.9147 to .9193	.9125 to .9183
Almond	.9186	.9154 to .9200
Peanut	.9186 to .9188	.9110 to .9220
Cotton-seed	.9226 to .9236	.9160 to .9362
Sesame	.9218	.9200 to .9250
Maize	.9233 to .9256	.9213 to .9255
Sunflower	.9201 to .9205	.9240 to .9262
Poppy	.9239 to .9244	.9240 to .9370

INDEX OF REFRACTION.

This determination was made with a Zeiss butyro-refractometer, the readings being made as nearly at 15.5° C. as possible. As it is not always convenient to make the readings at this temperature, the factor to be used for the correction for temperature was determined on oils likely to be used as substitutes for olive oil.[b] The butyro-refractometer, on account of its ease of manipulation, is very widely used, but its empirical scale, with divisions of varying value in refractive indices, requires for an accurate correction for temperature that the scale readings be calculated to indices of refraction and the temperature correction applied thereto. The reason for this can be seen from Table V.

[a] Rev. Int. Fals. Alim., 1899, **12**: 84.

[b] Tolman and Munson, Jour. Amer. Chem. Soc., 1902, **24**: 754.

TABLE V.—*Value of butyro-refractometer degrees in refractive indices on different parts of the scale.*

Scale division.	N_d.	Difference.
0	1.4220	0.0080
10	1.4300	
40	1.4524	.0069
50	1.4593	
90	1.4840	.0055
100	1.4895	

From this it will be seen that ten scale divisions from 0 to 10 on this instrument equal 0.0080 in index of refraction, while from 90 to 100 they equal 0.0055. It is evident that if, as shown in Table VII, the change in the refractive index for 1° C. is practically a constant, then the change in the scale division of this instrument for 1° C. must be a variable and will increase as the scale reading increases. This is shown in Table VI, which gives the readings on rape oil. The change for 1° C. decreases as the temperature rises.

TABLE VI.—*Variable temperature correction in butyro-refractometer readings.*

Temperature.	Scale readings.	Change for 1° C.	
		In scale reading.	In refractive index.
	Degrees.	*Degree.*	
2.8° C.	82.0	0.60	0.000360
21.8° C.	70.5		
21.8° C.	70.5	.57	.000360
38.4° C.	61.0		

Table VII gives the determinations of the temperature corrections of various oils.

TABLE VII.—*Temperature corrections for various oils.*

Laboratory No.	Kind of oil.	First reading.		Second reading.		Third reading.		Increase for 1° C.		
		Temperature.	Butyro-refractometer reading.	Temperature.	Butyro-refractometer reading.	Temperature.	Butyro-refractometer reading.	Between first and second reading.	Between second and third reading.	In index of refraction.
		° C.	*Degrees.*	° C.	*Degrees.*	° C.	*Degrees.*	*Degree.*	*Degree.*	
23605	Olive	3.4	76.5	22.0	65.5	37.8	56.5	0.59	0.57	0.000366
506	do	3.2	76.0	22.2	64.8	36.8	56.5	.59	.57	.000366
23460	do	3.2	76.0	22.2	65.0	43.3	53.0	.58	.56	.000360
493	Poppy seed	9.0	82.5	19.9	75.6	41.0	63.2	.63	.59	.000369
491	Maize	2.8	84.5	21.8	73.0	39.6	62.5	.60	.59	.000366
498	Sunflower	3.0	81.0	21.8	69.5	39.0	59.5	.61	.58	.000369
23624	do	3.0	81.2	22.0	70.0	39.0	60.0	.59	.58	.000364
496	Rape	2.8	82.0	21.8	70.5	38.4	61.0	.60	.57	.000363
490	do	3.4	82.2	22.0	71.0	38.8	61.4	.60	.57	.000364
486	Mustard	2.8	84.5	22.0	72.5	38.0	63.2	.62	.58	.000360
495	Black mustard	3.2	84.5	22.0	73.0	39.4	63.0	.61	.57	.000361
487	Lard	3.0	74.5	22.0	63.4	37.6	54.6	.58	.56	.000363
22434	do	3.0	75.2	22.0	64.0	39.2	54.0	.59	.57	.000372
499	Peanut	3.0	78.5	22.0	67.2	37.2	58.5	.59	.57	.000365
23656	do	3.3	76.0	22.0	64.5	44.2	52.3	.61	.55	.000366
492	Peanut and cotton seed	3.4	82.0	22.0	70.5	42.5	58.8	.61	.57	.000369
489	Sesame	3.4	81.2	22.0	70.0	38.2	60.5	.60	.58	.000370
436	Cotton seed	3.4	81.5	22.2	70.0	37.6	61.2	.61	.57	.000368
	Average									.000365

From these results it is seen that the correction of the index of refraction for 1° C. is practically a constant for all of the oils examined, while the correction in scale divisions varies from 0.55 to 0.63 for 1° C. For great changes of temperature it is not accurate to use the scale division factor, but the results must be reduced to indices of refraction and the correction applied to them. The following formula may be used to correct for a range of 10 degrees:

$R = R' + X(T' - T)$.

R = reading corrected to T.

R′ = reading at T′.

T = desired temperature.

T′ = temperature at which readings are made.

X = change in scale division caused by a change of temperature of 1° C. (X = 0.55 for butters; 0.58 for oils that read from 60° to 70° on the scale; and 0.62 for oils that read from 70° to 80°.)

The determination of the index of refraction has much the same value in the detection of adulteration as the determination of specific gravity. The forty-two samples of California oils examined had a range of from 1.4703 to 1.4718, with an average of 1.4711. These limits exclude one sample having 44 per cent of free acid and an index of 1.4672, as free acid reduces the index of refraction of an oil. Blasdale[a] on eleven samples of California oils obtained a range of 1.4710 to 1.4716. Colby[b] gives a range for California oils of from 1.4689 to 1.4717, but this is probably too wide for oils which can be classed as salad oils. On eighteen samples of pure Italian oils reported in this bulletin there was found a range of from 1.4703 to 1.4713. There is therefore a total variation in the determinations made in this laboratory of from 1.4703 to 1.4713, with no difference between the California and Italian oils. Table VIII gives the index of refraction obtained on various oils.

TABLE VIII.—*Butyro-refractometer readings and refractive indices of oils.*

Kind of oil.	Number of samples.	Butyro-refractometer readings at 15.5° C.	Index of refraction at 15.5° C.
		Degrees.	
California olive	42	66.9 to 69.2	1.4703 to 1.4718
Italian olive	18	67.3 to 68.5	1.4706 to 1.4713
Lard	4	68.8 to 69.5	1.4702 to 1.4720
Almond	1	70.9	1.4728
Peanut	3	70.0 to 71.3	[c]1.4723 to 1.4731
Mustard	5	74.5 to 76.5	1.4750 to 1.4762
Rape	4	74.1 to 74.8	1.4748 to 1.4752
Sesame	1	73.3	1.4742
Sunflower	1	72.7	1.4739
Maize	4	75.6 to 77.5	1.4757 to 1.4768
Cotton-seed	4	72.3 to 75.6	1.4737 to 1.4757
Poppy	1	77.8	1.4770

[a] Jour. Amer. Chem. Soc., 1895, 17: 935.

[b] California Agri. Expt. Sta. Rept., 1897–98, p. 169.

[c] One sample of peanut oil containing 13.51 per cent of free acids had an index of refraction of 1.4707.

Maumené Number[a] and Specific Temperature Reaction.[b]

The method used in making this determination was that described in the Provisional Methods for the Analysis of Foods.[c]

The specific temperature number was calculated by the following formula:

$$S = \frac{100\ A}{B}.$$

S = Specific temperature number.
A = Maumené number.
B = The rise of temperature obtained with pure water under the same conditions as those used in the Maumené test.

This simple test if carried out properly is a most valuable and rapid means of judging the purity of olive oil. Lard oil is practically the only oil which would be used as a substitute that has as low a figure.

Different analysts have obtained widely varying figures for this test, but it is easily shown that these are due to the use of acids of varying strength. Colby,[d] in preparing standards for the Association of Official Agricultural Chemists, gives from published results a range for this test of 32 to 47; but such figures as these have no value as they represent results obtained by different methods and different strengths of acid. Blasdale[e] found on a number of California oils a range of 45 to 47. With the 42 samples of California oils of known purity examined in this laboratory a range of 43.5 to 52.1 was found, with an average of 46.8. In contrast to these results, Milliau,[f] in his report on the oils of Tunis, gives a range of 30 to 36. These figures represent the variation found in 50 samples of oils from varied sources and processes of manufacture. Milliau,[g] in an earlier report on the olive oils of Europe, gives a range for the Maumené figure of 30 to 35. This wide difference in results is due entirely to the strength of the acid used in making the test. The actual limits where the same method and the same strength of acid are used are quite narrow. In preparing acid for this test Milliau[h] diluted 95 parts by volume of pure 66° Baumé acid with 5 parts of distilled water. The acid prepared in this way gives a rise of temperature with water of about 38° C., and compares satisfactorily when calculated to the specific temperature number with results obtained by the use of strong acid giving a rise of temperature with water of 45 to 46° C. In this laboratory an acid with a specific gravity of 1.844 was used, which gave a rise of temperature

[a] Comp. Rend., 1852, **35**: 572.
[b] Thomson and Ballantyne, Jour. Soc. Chem. Ind. 1891, **10**: 233.
[c] U. S. Dept. Agr., Bureau of Chemistry Bul. 65, p. 31.
[d] California Expt. Sta. Rept., 1897–98, p. 169.
[e] Jour. Amer. Chem. Soc., 1895, **17**: 935.
[f] Milliau, Bertainchand and Malet, Rapport sur les huiles d'olive de Tunisie, 1900.
[g] Bul. du Ministère de l'Agriculture, 1895, p. 139.
[h] Buletinul camerei de comerciu si industrie din Bucuresci, 1900.

with water of 45° C. Thus it can be seen that the Maumené numbers alone have no comparative value. Either the exact strength of the acid must be given, or, perhaps better, the rise of temperature with water under standard conditions.

Thomson and Ballantyne,[a] in order to give these results a comparative value, proposed to report them as specific temperature numbers. They showed that with acid varying from 95.4 to 99 per cent there was only a very slight difference in results when calculated to specific temperature numbers, the stronger acid giving slightly higher results. Sherman, Danziger, and Kohnstamm[b] showed that if there was a much greater variation in the strength of acid used there was also a wider variation in the specific temperature numbers. With acid varying in strength from 89 to 95 per cent they found an average of from 90 to 103 in specific temperature numbers on the same olive oil.

The Maumené numbers obtained by the writers on 32 samples of olive oil of known purity using different strengths of acid are given in Table IX.

TABLE IX.—*Maumené and specific temperature numbers of olive oils.*

Serial number.	Rise of temperature given with pure water.	Maumené number.	Specific temperature number.	Rise of temperature given with pure water.	Maumené number.	Specific temperature number.	Rise of temperature given with pure water.	Maumené number.	Specific temperature number.
	°C.			°C.			°C.		
962	33.3	31.4	94.3				43.9	43.5	99.1
960	33.3	29.8	89.4				43.9	44.7	101.8
934	33.3	29.6	88.9				43.9	42.5	96.8
836	34.0	30.0	88.2	37.7	36.6	97.0	45.6	48.2	105.7
931	34.0	29.8	87.6				45.6	44.4	97.4
932	34.0	30.6	90.0	37.7	33.2	88.0	45.6	44.4	97.4
933	34.4	27.4	79.6	37.7	33.4	88.6	45.6	43.5	95.4
935	34.4	27.1	78.8				45.6	44.2	97.0
955	34.4	27.5	79.9				45.6	44.2	97.0
961	34.4	28.7	83.4				45.6	43.5	95.4
936	34.4	28.6	83.1				45.6	44.8	98.2
959				35.6	28.8	80.9	47.5	46.2	97.2
953				35.6	31.6	88.8	47.5	47.0	99.0
954				35.6	31.3	88.0	47.5	48.3	101.7
956				35.6	31.5	88.5	47.5	49.1	103.4
957				35.6	29.0	81.4	47.5	45.0	94.7
952				35.6	28.0	78.6	47.5	45.0	94.7
958				35.6	29.4	82.6	47.5	48.0	101.0
835				37.7	35.9	95.2	45.5	44.8	98.5
838				37.7	37.7	100.0	45.5	49.5	108.8
837				37.7	35.4	93.9	45.5	45.0	98.9
840				37.7	37.5	99.5	45.5	48.2	105.9
839				37.7	38.9	103.1	45.5	48.4	106.4
834				38.5	36.1	93.8	47.5	46.2	97.2
833				38.5	36.8	96.5	47.5	48.0	101.0
832				38.5	37.1	96.4	47.5	47.6	100.1
831				38.5	36.0	93.5	47.5	46.6	98.1
795				38.5	37.7	97.8	47.5	50.0	106.2
796				38.5	39.1	101.5	47.5	52.1	109.7
797				38.5	38.4	99.7	47.5	50.2	105.6
798				38.5	39.1	101.5	47.5	51.0	107.3
Maximum	34.4	31.4	94.3	38.5	39.1	103.1	47.5	52.1	109.7
Minimum	33.3	27.1	78.8	35.6	28.0	78.6	43.9	42.5	94.7
Difference	1.1	4.3	15.5	2.9	11.1	24.5	3.6	9.6	15.0

The results given in this table show that when there is a wide difference in the strength of acids used the specific temperature numbers

[a] Jour. Soc. Chem. Ind., 1891, **10**: 233.

[b] Jour. Amer. Chem. Soc., 1902, **24**: 266.

are not of much value for comparative purposes, but if there is only a slight difference in strength they give very satisfactory results. The variation is least when a strong acid is used, giving a rise of temperature with water of 43.9° C. to 47.5° C., showing that the Maumené number obtained on olive oils with strong acid is more uniform than with the weaker acid. However, the strong acid is not satisfactory for use on seed oils, as the reaction becomes too violent and the oil is broken up. With seed oils a weaker acid was used, as suggested by Sherman, Danziger, and Kohnstamm.[a]

The following table gives the results obtained in this laboratory on various oils. The strongest acid was used on the olive and lard oils, and a weaker acid on the seed oils.

TABLE X.—*Maumené and specific temperature numbers of various oils.*

Kind of oil.	Maumené number.	Specific temperature number.[a]	Kind of oil.	Maumené number.	Specific temperature number.[a]
California olive	42.5 to 52.0	94.7 to 109.7	Almond	45.3	117.6
Italian olive	42.5 to 49.1	95.6 to 104.7	Sesame	61.3	170.3
Lard	46.5 to 47.8	103.3 to 106.2	Sunflower	60.0	166.7
Peanut	61.0 to 63.2	135.5 to 140.2	Maize	75.2 to 89.2	190.2 to 212.5
Mustard	61.0 to 79.4	130.9 to 190.3	Cotton seed	66.2 to 73.4	172.4 to 191.1
Rape	54.5 to 67.8	135.0 to 152.5	Poppy	75.8 to 85.5	213.0 to 237.0

[a] Acids of quite widely differing strengths were used in these determinations.

IODIN ABSORPTION.

The method used for this determination was the modified Hübl method, as adopted by the Association of Official Agricultural Chemists,[b] in which the iodin solution is allowed to stand in contact with the oil for three hours.

The iodin number was found to be exceedingly variable. On 42 samples of California oil examined the range was 78.5 to 89.8, with an average of 85.1. Blasdale[c] found a range of from 80 to 86.5, with an average of 84. Colby[d] gives a range of 77.7 to 93.5 for California oils of known purity. On 17 samples of Italian oils the variation was from 79.2 to 86.1, with an average of 81.5. De Negri and Fabris[e] found on 88 samples of pure Italian oils a range of from 79.1 to 89.8, with an average of 83.7. Milliau[f] found for French oils a range of from 84 to 85, and for the oils of southern Europe and Tunis a range of from 81.4 to 85.2. Later[g] he found on Tunis oils a range of 79.3 to 89.5, with an average of 85, figures which are very similar to the

[a] Jour. Amer. Chem. Soc., 1902, **24**: 266.

[b] U. S. Dept. Agr., Division of Chemistry Bul. 46, p. 50; Bul. 65, p. 24.

[c] Jour. Amer. Chem. Soc., 1895, **17**: 935.

[d] California Agr. Expt. Sta. Rept., 1897–98, p. 168.

[e] Annali del Labor. chim. centr. delle Gabelle, vol. 1, Gli Olii, pt. 1, p. 38.

[f] Bul. du Ministère de l'Agriculture, 1895, p. 139.

[g] Milliau, Bertainchand, and Malet, Rapport sur les huiles d'olive de Tunisie, 1900.

results obtained on California oils. From these results it would seem that the range of iodin numbers on California oils is from 78 to 90, a little wider than that found on French oils, but about the same as on Italian and Algerian oils.

Table XI gives the range of iodin values found in this laboratory and by other analysts on various oils of known purity. With all these oils this range is extremely wide, and for this reason the determination of the iodin value is by itself of little value as a means of detecting adulteration. Only in cases of gross adulteration could it be conclusive. By a careful selection of the oils to be used in making the mixture, large proportions of either lard or peanut oil could be used without producing an abnormal iodin value. As is shown in Table XVII, page 26, the iodin value increases as the solid fatty acids and the melting point of the fatty acids decrease. It is only when this factor is determined, in connection with these other factors and with the iodin value of the liquid fatty acids, that it may serve as a valuable indication of the purity of an oil.

TABLE XI.—*The Hübl number of various oils.*

Kind of oil.	Results obtained in the Bureau of Chemistry.	Compiled results.	Kind of oil.	Results obtained in the Bureau of Chemistry.	Compiled results.
California olive	78.5 to 89.8	77.7 to 93.5	Cotton-seed	103.8 to 110.9	106.5 to 110.7
Italian olive	79.2 to 86.1	79.0 to 89.8	Sesame	106.6	102.0 to 112.0
French olive		84.1 to 84.5	Rape	92.5 to 101.2	94.1 to 106.2
Algerian olive		79.3 to 89.5	Mustard	98.4 to 113.0	92.1 to 105.5
Lard	69.7 to 77.2	60.0 to 82.0	Maize	116.7 to 123.3	111.1 to 123.9
Almond	96.2	93.0 to 102.0	Sunflower	104.1 to 108.3	119.0 to 125.0
Peanut	87.8 to 96.3	85.6 to 105.0	Poppy	133.2 to 134.9	130.5 to 141.0

The Hübl method has never been considered entirely satisfactory, owing to the poor keeping quality and the slowness of reaction of the iodin solution used. Recently two new solutions have been proposed as substitutes, both of which, it is claimed, remain practically unchanged for several months[a] and are more rapid in their reaction than the Hübl solution. The Wijs[b] solution consists of iodin mono-chlorid dissolved in glacial acetic acid; the other, proposed later by Hanus,[c] is a solution of iodin mono-bromid in glacial acetic acid. Comparative tests of these two solutions with the Hübl solution, made upon a large number of olive and other oils, verify the claims made for these new solutions both as regards their keeping qualities and their rapidity of action. A comparison of these methods is given in Table XII.

[a] Tolman and Munson, Jour. Amer. Chem. Soc., 1903, **25**: 244.

[b] Ber. 1898, **31**: 752.

[c] Ztschr. Nahr. u. Genussm., 1901, **4**: 913.

TABLE XII.—*Iodin numbers of olive oils.*

Laboratory No.	Hübl number (3 hours).	Wijs number (30 minutes).	Hanus number (30 minutes).	Difference between Wijs and Hübl numbers.	Difference between Hanus and Hübl numbers.
795	89.7	90.9	90.4	+1.2	+0.7
796	89.7	90.6	90.0	+ .9	+ .3
797	89.8	91.4	90.0	+1.6	+ .2
798	89.7	91.1	90.4	+1.4	+ .7
960	80.9	82.5	81.7	+1.6	+ .8
833	84.8	86.7	86.5	+1.9	+1.7
831	85.2	86.7	85.9	+1.5	+ .7
832	84.9	86.5	85.9	+1.6	+1.0
834	84.5	86.1	85.1	+1.6	+ .6
936	81.8	82.8	82.8	+1.0	+1.0
933	80.6	81.6	81.1	+1.0	+ .5
835	82.7	83.1	82.6	+ .4	− .1
962	81.2	81.5	80.9	+ .3	− .3
955	82.6	83.6	83.1	+1.0	+ .5
952	81.3	82.2	81.8	+ .9	+ .5
840	86.3	87.8	86.7	+1.5	+ .4
935	80.5	80.9	81.6	+ .4	+1.1
953	79.2	79.9	80.6	+ .7	+1.4
958	81.8	83.1	81.8	+1.3	0.0
959	81.4	83.4	81.9	+2.0	+ .5
954	86.1	87.7	86.3	+1.6	+ .2
934	81.1	82.4	82.3	+1.3	+1.1
956	84.5	85.9	85.6	+1.4	+1.1
932	80.5	82.0	81.4	+1.5	+ .9
961	80.8	82.3	81.1	+1.5	+ .3
836	86.0	87.7	86.6	+1.7	+ .6
931	80.7	82.2	81.5	+1.5	+ .8
838	86.1	87.9	87.1	+1.8	+1.0
839	89.0	91,3	89.9	+2.3	+ .9
837	84.0	.....	84.9	.....	+ .9
673	83.3	84.1	82.6	+ .8	− .7
841	86.9	88.0	87.3	+1.1	+ .4
842	87.2	88.1	87.1	+ .9	+ .1
843	85.1	86.6	85.6	+1.5	+ .5
844	84.2	85.0	84.2	+ .8	0.0
1091	81.9	83.4	82.0	+1.5	+ .1
Average (36 samples)	.....	.....	.....	+1.3	+0.60
Maximum	.....	.....	.....	2.3	1.7
Minimum	.....	.....	.....	0.3	0.0

Table XII gives the results obtained upon olive oils and Table XIII the results obtained upon other nondrying oils, semidrying, and drying oils. The values obtained with olive oils are slightly higher when the Wijs or the Hanus solution is used, but the difference is not sufficient to materially change the standard already existing for this oil. With other oils having a low iodin value closely agreeing results were obtained by the three methods, as shown in the values obtained for oleo oil, butter, and lard. With mustard and rape oil of the nondrying oils, and linseed oil of the drying oils, much higher results were obtained by the Wijs and the Hanus methods, and the use of either of these will necessitate the establishment of new standards.

TABLE XIII.—*Iodin numbers of various oils and fats.*

Laboratory No.	Oils and fats.	Hübl number (3 hours).	Wijs number (30 minutes).	Hanus number (30 minutes).	Difference between Wijs and Hübl numbers.	Difference between Hanus and Hübl numbers.
	FATS.					
	Cocoanut	8.93	9.05	8.60	+ 0.12	− 0.33
	Konut[a]	6.09	6.43	6.40	+ .34	+ .31
1170	Butter	35.3	36.2	35.3	+ .90	+ .00
1168	.....do	34.8	35.9	35.4	+ 1.10	+ .60
	Oleo	42.6	43.5	43.3	+ .90	+ .70
	Oleomargarine	53.6	53.5	52.3	− .10	− 1.30
	.....do	52.8	53.7	52.2	+ .90	− .60
	.....do	52.5	52.9	52.0	+ .40	− .50
	.....do	66.3	66.0	64.8	− .30	− 1.50
	NONDRYING OILS.					
23606	Lard	69.3	70.5	69.8	+ 1.20	+ .50
487	.....do.[a]	73.7	74.5	73.9	+ .70	+ .20
1181	Magnolia	81.7	79.4	78.9	− 2.30	− 2.80
1182	.....do	76.1	75.6	74.0	− .50	− 2.10
772	Peanut	96.3	99.0	97.4	+ 3.00	+ 1.10
1149	.....do	94.5	95.2	94.1	+ .70	− .10
492	.....do.[b]	107.7	109.5	107.7	+ 1.80	+ .00
770	Mustard	110.4	118.5	115.5	+ 8.10	+ 5.10
771	.....do	113.0	118.2	116.8	+ 5.20	+ 3.80
776	.....do	98.4	104.3	103.8	+ 5.90	+ 5.40
486	.....do.[a]	103.5	112.5	110.2	+ 9.00	+ 6.70
495	.....do.[a]	106.4	117.3	114.8	+10.90	+ 8.40
775	Rape	101.3	105.7	105.2	+ 4.40	+ 3.80
490	.....do.[a]	100.2	104.1	102.8	+ 3.90	+ 2.60
	SEMIDRYING AND DRYING OILS.					
	Sunflower	106.4	109.2	107.7	+ 2.80	+ .80
1159	Cottonseed	103.8	105.3	105.2	+ 1.50	+ 1.40
1160	.....do	106.2	107.3	107.8	+ 1.10	+ 1.60
1161	.....do	104.8	106.2	106.7	+ 1.40	+ 1.90
489	Sesame[a]	106.4	107.0	106.5	+ .60	+ .10
444	Maize[a]	119.0	123.2	120.2	+ 4.20	+ 1.20
491	.....do.[a]	119.0	122.2	119.6	+ 3.00	+ .40
777	.....do	123.3	129.2	126.0	+ 5.80	+ 2.70
493	Poppy[a]	133.4	135.2	132.9	+ 1.80	− .50
774	.....do	134.9	139.1	138.4	+ 4.20	+ 3.50
1162	Linseed[a]	169.8	186.5	184.5	+16.70	+14.70
1188	.....do.[c]	179.5	188.7	183.7	+ 9.20	+ 4.20

[a] Commercial oils.
[b] Adulterated with cotton-seed oil.
[c] Four hours for Hübl determination.

As will be seen from Table XIV, the length of time involved in the determination is greatly lessened by the use of the Wijs and the Hanus solutions. In case of olive oils the reaction is complete in fifteen minutes; cotton seed, sesame, mustard, and other nondrying and semidrying oils require thirty minutes; while rape and linseed oils require one hour for complete absorption.

TABLE XIV.—*Time necessary for absorption of iodin.*

Laboratory No.	Kind of oil or fat.	Iodin numbers by Hanus method.			Iodin numbers by Wijs method.		
		15 minutes.	30 minutes.	1 hour.	15 minutes.	30 minutes.	1 hour.
773	Cocoanut	8.7	8.6	.....	.....	.....	.....
22077	Konut	6.4	6.4	.....	.....	.....	.....
1170	Butter	35.2	35.4	.....	.....	.....	.....
1168	.....do	35.4	35.5	.....	35.8	35.9	36.0
	Oleo	43.2	43.4	.....	.....	.....	.....
	Oleomargarine	52.4	51.8	.....	.....	.....	.....
	.....do	51.9	52.1	.....	52.9	.....	53.0
	.....do	64.6	65.1	.....	.....	.....	.....
	.....do	52.2	52.4	.....	.....	.....	.....
	.....do	80.4	80.5	.....	.....	.....	.....
23606	Lard	70.0	69.7	.....	.....	.....	.....
798	Olive	90.1	90.4	90.3	90.0	91.2	90.9
960	.....do	82.1	81.7	82.2	82.6	82.6	82.5
833	.....do	86.5	86.5	86.5	86.5	86.7	87.2
772	Peanut	96.0	97.4	97.7	98.8	99.0	99.0
777	Mustard	125.0	126.0	126.0	126.5	126.5	128.0
771	.....do	.....	119.4	120.0	.....	118.0	118.2
776	.....do	.....	105.0	105.0	.....	104.3	104.6
775	Rape	.....	107.4	107.5	.....	105.8	105.7
770	Maize	.....	116.8	117.6	117.1	116.1	118.5
774	Poppy	136.8	137.4	138.4	138.8	138.9	139.1
1162	Linseed	.....	186.3	186.2	183.8	190.2	188.7

These results show but little choice between the two new solutions, the Hanus solution giving results slightly closer to the figures obtained by the Hübl method.

The Wijs solution is prepared by dissolving 13 grams of pure iodin in a liter of glacial acetic acid which does not reduce a solution of bichromate of potash in sulphuric acid; a current of pure chlorin gas is run into the solution until the halogen content is doubled. A slight excess of iodin is recommended. The change of color in the solution as the end point is approached is quite marked.

The Hanus solution used is made by dissolving 13 grams of iodin in a liter of glacial acetic acid and then adding sufficient bromin to double the halogen content; about 3 cc are sufficient.

The method of using these solutions is the same as with the Hübl solution except that an excess of unabsorbed iodin of at least 70 per cent of the total titer is necessary; and only 10 cc of the 20 per cent potassium iodid solution are used, the solution being thoroughly mixed before the water is added. In the above work the absorption was allowed to continue thirty minutes, as some of the adulterants of olive oil require a slightly longer time than the oil itself to complete the absorption.

Great care must be taken that no change of temperature occurs while measuring the solutions. The high coefficient of expansion of acetic acid (0.00115 for 1° C.) will cause an appreciable error if even a slight change of temperature takes place. If 40 cc of these solutions are measured, a change in temperature of $\pm$ 1° C. will give a change of $\mp$ 0.11 cc in the amount of N/10 thiosulphate used to neutralize them. Table XV shows how great the variation in titer may be in a change of temperature of 11° C.

TABLE XV.—*Influence of temperature on titer.*

Temperature.	40 cc iodin-monobromid in N/10 thio-sul-
°C.	cc.
16	92.05
17.5	91.85
18.5	91.80
21.5	91.35
24.5	91.10
27	90.80
+11	—1.25

The results of this investigation show that either of the two new methods gives satisfactory results and that both solutions are decided improvements over the Hübl solution, not only in possessing much better keeping qualities, but also in rapidity of action. The Hanus solution gives results somewhat closer to those obtained by the Hübl method, and is much more easily prepared than the Wijs solution.

SAPONIFICATION OR KOETTSTORFER NUMBER.

The saponification number, or number of milligrams of potassium hydroxid needed to saponify 1 gram of fat, was determined as directed by the Association of Official Agricultural Chemists.[a] The determination has little value in detecting adulteration of olive oil with any of the animal or vegetable oils except rape or mustard. Its chief value is in the detection of mineral oils.

Table XVI, giving the limits on various oils, shows the uniformity of the Koettstorfer number of the ordinary salad oils, except rape and mustard oil. The variation on the oils other than rape and mustard is from 185.0 to 197.7, while the variation on olive oils is from 185.0 to 194.6.

TABLE XVI.—*Saponification or Koettstorfer number of various oils.*

Kind of oil.	Results obtained in Bureau of Chemistry.	Compiled results.	Kind of oil.	Results obtained in Bureau of Chemistry.	Compiled results.
California olive	189.3 to 194.6	187.0 to 193.5	Peanut	188.8 to 196.0	189.3 to 196.0
Italian olive	189.7 to 192.0	185.0 to 192.3	Cotton seed	196.0 to 198.5	191.0 to 196.6
Lard	195.3 to 197.7	189.5 to 196.0	Sesame	190.7	188.4 to 194.6
Rape	174.1 to 176.6	167.7 to 183.0	Maize	189.9 to 193.4	188.0 to 193.4
Mustard	173.0 to 182.8	170.2 to 174.7	Sunflower	191.2 to 192.3	188.0 to 197.6
Almond	192.5	183.0 to 191.7	Poppy seed	190.2 to 193.8	192.8 to 194.0

MELTING POINT OF FATTY ACIDS.

The method used for this determination was that described in the Provisional Methods for Food Analysis.[b] A variation was found on

[a] U. S. Dept. Agr., Division of Chemistry Bul. 46, p. 48.

[b] U. S. Dept. Agr., Bureau of Chemistry Bul. 65, p. 31.

California oils of known purity of from 19.2° to 31° with an average of 22.5°. Blasdale[a] found the variation on eleven samples of California oils to be from 21° to 26°, and Colby[b] gives a range of from 21° to 28°. On Italian oils the writers found a variation of from 21° to 29.3°. Other published results give a variation of 23.7° to 29°. Milliau[c] reports on French oils 24° to 26°, but on Algerian[d] oils gives a range of from 24.8° to 38°. This shows that Algerian oils are quite different from the European and Californian products.

Table XVII, prepared from Table XXXV, shows the relation between the Hübl number, percentage of solid fatty acids, and melting point of fatty acids in California olive oils. The writers found that in a general way the same relation held good for Italian oils. Milliau[d] did not find this relation to hold on oils from Tunis. He found oils with a Hübl number of 88 and a melting point of fatty acids of 37° C., and concluded from this that there were fatty acids present more unsaturated than oleic acid.

TABLE XVII.—*Relation between Hübl number, solid fatty acids, and melting point of fatty acids (California oils).*

Serial No.	Hübl number.	Solid fatty acids.	Melting point of fatty acids.	Serial No.	Hübl number.	Solid fatty acids.	Melting point of fatty acids.
		Per cent.	°*C.*			*Per cent.*	°*C.*
23462	79.9	10.91	31.0	23463	85.6	4.92	21.3
23461	83.0	7.62	28.0	23460	85.7	6.27	23.4
23459	82.9	5.70	25.0	23457	86.2	3.39	21.1
23456	84.3	7.23	23.4	23458	88.2	4.42	23.5
23692	85.6	5.12	22.6	23605	88.5	2.43	20.2

The melting points of the fatty acids of peanut oil, cotton-seed oil, and lard oil are so much higher than those of the mixed acids of olive oil that any considerable addition of any one of these oils to olive oil would produce an abnormal melting point. This is especially true of lard oil and cotton-seed oil. Sesame oil varies but little from olive oil in respect to the melting point of its fatty acids, but oils of rape seed, mustard seed, sunflower, poppy seed, and maize are appreciably lower. Since, however, none of these would probably be mixed with any but olive oil or some one of the oils having a higher melting point than olive oil, this difference would be of little value in the detection of their substitution for olive oil. The determination of the melting point in itself has little value in the detection of adulteration, but is of decided value when taken in connection with other factors in judging whether or not the oil is normal. The melting points of the fatty

[a] Jour. Amer. Chem. Soc., 1895, 17; 935.

[b] California Agr. Expt. Sta. Rept., 1897–98, p. 169.

[c] Bul. du Ministère de l'Agriculture, 1895, p. 139.

[d] Milliau, Bertainchand, and Malet, Rapport sur les huiles d'olive de Tunisie, 1900.

acids of various oils as determined in this laboratory and as found in the literature on the subject are given in Table XVIII.

TABLE XVIII.—*Melting point of fatty acids of various oils.*

Kind of oil.	Results obtained in Bureau of Chemistry.	Compiled results.	Kind of oil.	Results obtained in Bureau of Chemistry.	Compiled results.
	°C.	°C.		°C.	°C.
California olive ..	19.2 to 31.0	21.0 to 28.0	Sunflower.....	21.0	17.0 to 24.0
Italian olive.....	21.6 to 29.3	23.7 to 29.0	Maize	21.6 to 23.0	16.0 to 22.4
French olive	.....	24.0 to 26.0	Poppy.....	25.4 to 25.8	20.0 to 21.0
Algerian olive....	.....	24.8 to 38.0	Sesame.....	27.4	21.0 to 40.0
Almond	23.2	12.0 to 14.0	Peanut.....	33.2 to 37.6	26.0 to 36.4
Mustard	20.8 to 21.5	15.0 to 21.5	Lard	33.2 to 38.4	33.0 to 38.4
Rape	20.0 to 21.9	15.5 to 22.0	Cotton seed	35.5 to 39.6	32.0 to 43.0

SOLID FATTY ACIDS.

By solid fatty acids are meant those whose lead salts are insoluble in ether. The method of determination used was that described in the Provisional Methods for Food Analysis.[a] From these results, calculating the average total fatty acids present as 95.5 per cent,[b] the percentage of liquid fatty acids can be obtained. As the latter are the unsaturated fatty acids and alone absorb the iodin, the percentage of these acids and their iodin value gives a fair idea of the nature of the oil under consideration. Some of the oils of Tunis must contain fatty acids more unsaturated than oleic to give the high iodin number, and also the high per cent of solid fatty acids found by Milliau, Bertainchand, and Malet.[b]

The iodin number of the oil multiplied by 100 and divided by the per cent of liquid fatty acids will give their iodin number, providing the solid fatty acids are saturated. The calculated results agree fairly well with those obtained by experiment. These results show that in olive oils the unsaturated fatty acids are variable in their composition and can not be considered as pure oleic acid.

From Table XXXIII it is seen that in lard oil the unsaturated fatty acids have practically the same iodin number as the unsaturated acids of olive oil. Rape-seed oil does not differ much in this respect from olive oil. Mixtures of lard and cotton-seed oils which would give a normal iodin number for olive oil would have a much higher iodin number for the liquid acids. The relations between the solid fatty acids, the iodin number of the oil, and the liquid fatty acids, are of great value in identifying an oil of unknown origin. These factors for various oils are given in Table XIX. It can be seen from this table that the mixing of these oils with olive oil will change the figures on the mixture in a number of ways. An addition of maize oil would increase the iodin number of both the oil and the liquid fatty acids, but

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 65, p. 28.

[a] Rapport sur les huiles d'olive de Tunisie, 1900.

would not affect the solid fatty acids. Cotton-seed oil would increase all of these figures.

TABLE XIX.—*The Iodin numbers and the per cent of solid fatty acids of various oils.*

Kind of oil.	Hübl number.	Iodin number of liquid fatty acids.	Solid fatty acids.	Kind of oil.	Hübl number.	Iodin number of liquid fatty acids.	Solid fatty acids.
			Per cent.				*Per cent.*
Poppy	134.9	151.7	6.67	Sunflower	108.3	117.8	3.67
Maize	123.3	139.8	7.44	Do	104.1	113.8	4.12
Do	119.7	134.8	6.70	Rape	92.5	96.9	.12
Do	119.2	134.5	6.98	Do	101.2	107.5	1.43
Mustard	113.0	121.1	2.32	Sesame	97.9	115.4	10.70
Do	110.4	116.8	1.06	Lard	75.9	98.9	18.90
Do	98.4	103.0	Trace.	Do	69.7	101.3	26.68
Cotton-seed	108.3	141.5	19.04	Do	72.5	97.9	21.43
Do	105.8	136.3	17.87	Do	77.2	101.3	19.30

The addition of mustard oil would increase the iodin numbers, but decrease the solid fatty acids. Lard oil would decrease the Hübl number and increase the solid fatty acids, but would not affect the iodin number of the liquid fatty acids. In many cases, however, especially if but small amounts were added to olive oil, the changes in the factors would be so slight as to give no indication of any adulteration.

FREE FATTY ACIDS.

The free fatty acids were determined by the method described in the Provisional Methods for Food Analysis[a] and the results calculated as oleic acid. One cubic centimeter of deci-normal alkali is equal to 0.0282 gram of oleic acid. This determination is of considerable value, in that it gives some idea of the condition of the oil. As a rule this figure increases with age and may be to some extent an index of the rancidity of the oil. The amount of free acid greatly affects the physical constants of oils as has already been shown. All oils have some free acid present, even when freshly pressed. Its amount probably depends on the condition of the fruit or seed and the processes of manufacture. Milliau, Bertainchand, and Malet[b] found as high as 3.9 per cent of free acid in freshly pressed olive oil, probably due to the overripe or decayed condition of the olives.

With a number of cold-pressed seed oils manufactured in this laboratory the determination of free fatty acids was made within three days after the oils were pressed, with the following results: Sunflower oils, 0.18 and 1.72 per cent; peanut oil, 0.04 per cent; mustard-seed oil, 1.13 per cent; and rape-seed oil, 0.63 per cent. These figures show the presence of considerable amounts of free acids in the seeds. In Table XX are given the data showing the quantity of free acid in

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 65, p. 27.

[b] Rapport sur les huiles d'olive de Tunisie, 1900.

a number of samples of olive oil of known history. Nos. 22617, 22714, and 23126 all show an acidity that might be considered normal for fresh oils, although eight and ten years old. On the other hand Nos. 22618 and 22619, which were three years and one year old, respectively, show an excessive amount of free acid. It therefore follows that the time factor has but little influence upon the acidity, while No. 22619 indicates that high temperature favors the formation of the free acids.

TABLE XX.—*Free acids in olive oils.*

Serial No.	Free fatty acids as oleic.	History of sample.
	Per cent.	
22617	0.36	Made in 1893 from Redding Picholine olives.
22618	8.21	Made in 1898 from mixed varieties of olives.
22619	44.40	Made in 1900 from Manzanillo olives by strongly heating the fruit.
22714	1.26	Second pressing, 10 years old.
22715	2.73	Poor quality of oil, not an edible oil.
22126	1.40	South American oils exhibited at Chicago in 1893.
22127	4.33	

Eleven samples of pure California olive oils, all of which were considered fresh oils, gave an average content of free acid of 1.16 per cent, and the extremes were 0.59 per cent and 2.24 per cent. Twelve samples of commercial California olive oils in which no added oil was detected contained an average of 2.40 per cent free acids, and this figure is more nearly in accord with the averages of the French and Italian commercial oils than is the average given for the California oils of known purity. This is undoubtedly due to the fact that previous to leaving the storeroom of the manufacturer the oil is kept under more favorable conditions of light and temperature than it receives after entering the retail stores.

By reference to Table XXXIII it is seen that lard oil, peanut oil, and the various seed oils show an appreciable content of free acids, differing in this respect but little from olive oils. Cotton-seed oil alone is an exception. This oil is refined by use of alkali, and so shows but small amounts of acidity and yields but little upon long standing.

The rancidity of oils and fats has been the subject of extensive study by various investigators, and opinions regarding its causes are extremely varied. Lewkowitsch[a] states that pure, nondrying oils when protected from air and light remain unchanged at ordinary temperatures; on exposure to light and air they undergo change, consisting of the development of butyric, isobutylacetic, and other volatile acids in small quantities, an increase in free acids, and the acquirement of a disagreeable smell and acrid taste. These changes the author considers due to direct oxidation by the oxygen of the air, this action being intensified by sunlight.

[a] Chem. anal. oils, fats, and waxes, 2d ed., p. 10.

Ballantyne[a] has shown that in many instances rancidity exists long before the formation of free acids, and that on the other hand free acids may be liberated long before the oil becomes rancid. A. Schmidt[b] states that an oil may have a high acidity without being rancid, and that the oil becomes rancid upon partial or complete oxidation of the free glycerin to aldehydes and ketones. Scalé[c] found that olive oil and lard contained no water soluble volatile acids in a fresh condition, but these acids developed with age and consequent rancidity of the oil and fat. Browne[d] has made a study of the changes incident to the development of rancidity in butter fat and records some interesting results. Table XXI, taken from his work, shows the effect of the development of rancidity upon the various values of the oil. As the rancidity develops there is a decided increase in the acid, saponification, ether, and Reichert values, a marked decrease in the iodin value and the percentage of insoluble acids, and a slight decrease in the percentage of glycerin.

TABLE XXI.—*Effect of development of rancidity upon butter fat (Browne).*

No. of sample.	Condition.	Acid value.	Saponification number.	Ether number.	Reichert number.	Hübl number.	Oleic acid (calculated).	Insoluble acids.	Glycerol.
							Per cent.	*Per cent.*	*Per cent.*
0	Fresh	0.48	228.1	227.6	15.63	34.95	38.79	.....	.....
0	1 week old	1.28	230.3	229.0	15.80	34.55	38.35	.....	.....
0	1 month old	10.90	241.0	230.1	17.00	28.40	31.52	.....	.....
0	2 months old	28.84	260.0	231.2	18.75	14.35	15.93	.....	.....
0	4 months old	30.00	262.1	232.1	19.80	11.15	12.38	.....	.....
0	8 months old	35.38	269.3	233.9	21.13	8.55	9.49	.....	.....
1a	Fresh	.45	229.9	229.5	.....	33.93	37.66	87.20	12.54
1b	Rancid	1.22	232.3	231.1	.....	29.96	33.26	86.80	12.40
2a	Fresh	.50	223.9	223.4	.....	34.49	38.28	88.96	12.21
2b	Rancid, 1 month old	7.09	233.7	226.6	.....	28.69	31.85	85.06	12.02
3a	Fresh	.55	232.6	232.1	.....	29.56	32.81	86.41	12.69
3b	Rancid, 2 months old	11.73	247.7	236.0	.....	19.76	21.93	80.42	12.35
4a	Fresh	.51	225.6	225.1	.....	34.92	38.76	88.46	12.33
4b	Rancid, 3 months old	14.80	245.3	230.5	.....	22.55	25.03	81.15	11.67

Rancidity may affect the physical and chemical values of oils and fats in several ways. If large amounts of free acid are formed and little oxidation takes place the specific gravity and index of refraction may be lowered and the iodin number very little affected. If oxidation has taken place there will be an increase in the specific gravity, index of refraction, and saponification number, and a decrease in the iodin number.

From the foregoing it is apparent that oils are extremely susceptible to change under the influence of light, air, and heat, and that deterioration is in a large measure prevented by the exclusion of air and

[a] Jour. Soc. Chem. Ind., 1891, **10**: 29.
[b] Ztschr. Anal. Chem., 1898, **37**: 301.
[c] Ztschr. Nahr.-Unt. Hyg. u. Waarenk., 1896, **10**: 239.
[d] Jour. Amer. Chem. Soc., 1899, **21**: 975.

sunlight and by proper temperature conditions. These facts are of material importance, as the pleasant flavor and agreeable odor of pure, fresh olive oil may be easily destroyed upon the development of rancidity, while if kept under proper conditions the oils will remain practically unchanged for a long time. From the chemist's standpoint rancidity may so affect the values of an oil as to make it abnormal in many respects, and in the interpretation of analytical data this fact must be given due consideration.

OLIVE OIL SUBSTITUTES.

Cotton-Seed Oil.

Cotton-seed oil is the chief adulterant of and substitute for olive oil in this country. It is used to a large extent under the name of salad oil, but is also frequently sold as olive oil, with which it is extensively mixed. The well-refined oil has a pleasant though characteristic taste and odor, and is much less inclined to become rancid than are olive oil and other oils used for salad purposes. The cotton-seed oil sold for salads is refined in part by the use of alkali, and this treatment removes all free, fatty acids. The samples of cotton-seed oil found upon the market all showed very low percentages of free, fatty acids due to the above treatment and to the tendency of this oil to remain stable. One sample of unpurified, cold pressed cotton-seed oil examined had 2.17 per cent of free acids, but practically all of this amount existed in the seed at the time of pressing, as free acids were determined within a few days after the oil was pressed.

Table XXII.—*Cotton-seed oil.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Per ct.*
De Negri and Fabris:[a]										
Minimum	0.9230	.....	.....	50.0	.....	106.5	191.8	34.0	.....	.....
Maximum	.9250	.....	.....	53.0	.....	110.7	194.7	39.0	.....	.....
Tolman and Munson:[b]										
Minimum	.9226	72.3	1.4737	66.2	172.4	103.8	.....	.....	.....	0.04
Maximum	.9236	75.6	1.4757	73.4	191.1	110.9	.....	.....	.....	2.17
Allen:[c]										
Minimum	.9160	.....	.....	74.0	163.0	102.0	191.0	35.0	32.2	.....
Maximum	.9300	.....	.....	77.0	170.0	111.0	196.6	40.0	37.6	.....
Lewkowitsch:[d]										
Minimum	.9250	.....	1.4747	75.5	.....	106.0	192.5	35.0	30.5	.....
Maximum						108.0		43.0	35.2	.....
Twenty-two other analysts:[e]										
Minimum	.9216	.....	.....	55.0	.....	104.5	191.0	32.0	.....	.....
Maximum	.9362	.....	.....	71.0	.....	114.0	195.0	43.0	.....	.....

[a] 10 samples. Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 92.
[b] 4 samples.
[c] Com. Org. Anal., 3d ed., vol. 2, pt. 1, p. 140.
[d] Oils, Fats, and Waxes, p. 374.
[e] Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 92.

Table XXII is a compilation of the results of a large number of analyses, and gives the limits which have been obtained for this oil. Some of these figures are so extraordinary that the oils from which they were obtained can hardly be considered otherwise than abnormal. In this bulletin the term "normal oils" is used to indicate those which are not so rancid as to be unfit to be eaten or which have not been oxidized by artificial means. On rancid or oxidized oils results can be obtained which are entirely different from those which would be found on fresh oils, and in this report salad oils only are considered. Cotton-seed oils with a specific gravity as low as 0.9160 and as high as 0.9360 are most likely abnormal. Such figures can hardly be considered of any value unless further data as to free acids and condition of the oils are known. In this connection samples Nos. 13235 and 23656 of peanut oil in Table XXXIII serve as examples. The first oil was what is called a "blown" oil, and the results obtained with it are entirely abnormal. It has a specific gravity of 0.9364, an iodin number of 77, and saponification number of 199. The second has a specific gravity of 0.9155, but has 13.51 per cent of free acid. Such an oil could not be used under any circumstances as salad oil, and certainly should not be considered in establishing limits for peanut oil.

When added in any considerable amounts to olive oil, cotton-seed oil is not difficult to detect, on account of its high specific gravity, iodin number, Maumené figure, and index of refraction. Moreover, there are the qualitative tests of Bechi, Halphen, and the nitric acid reaction to detect it in small amounts. The Halphen test[a] is extremely delicate, detecting 1 per cent or less of the unheated oil. This test is characteristic of cotton-seed oil, and if obtained in an olive oil is proof of its presence. But Holde and Pelgry[b] have shown that cotton-seed oil if heated for ten minutes to 250° C. loses the power of giving both the Halphen and Bechi tests. The writers found that it took twenty minutes to completely destroy the power to give the Halphen test, but the reaction was greatly weakened on oils heated a much shorter time. This heated oil if refined would lose the taste and odor due to heating and could be mixed with olive oil in small amounts without giving the Halphen, Bechi, or Milliau test. But the nitric acid reaction is apparently not affected in any way by this heating.

Tortelli and Ruggeri[c] have made an extensive study of heated cotton-seed oil in order to discover means of detecting it in olive oil. They found that it was necessary to heat the cotton-seed oil twenty minutes at 250° C. in order to completely destroy its power of reacting with Halphen or Bechi reagents. The values of the oil are not

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 65, p. 32.

[b] Chem. Rev. Fett. u. Hartz. Ind., 1899, 6: 67; Jour. Soc. Chem. Ind., 1899, 18: 711.

[c] Annali del Lab. chim. cent. delle Gabelle, 1900, p. 249.

affected to any great extent by this heating, as is shown in Table XXIII, taken from their work.

TABLE XXIII.—*Values of heated cotton-seed oil (Tortelli and Ruggeri).*

Temperature and time of heating.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Maumené number.	Hübl number.	Iodin number of liquid fatty acids.	Melting point of fatty acids.	Solidifying point of fatty acids.
		Degrees.				° *C.*	° *C.*
Original oil	0.9240	56.0	67.0	108.6	147.0	35.8	.....
200° C. for 10 minutes	.....	.....	.....	104.0	140.2	.....	.....
250° C. for 10 minutes	.....	.....	.....	103.8	138.3	.....	.....
Original oil	.9240	56.0	67.0	109.9	147.7	35.8	32.2
200° C. for 10 minutes	.9230	56.5	67.0	108.3	142.7	35.9	32.4
250° C. for 10 minutes	.9244	56.5	66.0	107.5	141.5	36.0	32.5
250° C. for 20 minutes	.9243	57.5	65.0	106.9	140.7	36.2	32.5

The iodin number of the liquid fatty acids is affected by heating to a greater degree than any other value, being considerably lowered. Tortelli and Ruggeri propose the following method for the detection of the heated oil which depends on the fact that while such an oil will not give the Halphen or Bechi test, the reacting substance is not entirely destroyed, and by concentrating this a reduction of silver is obtainable.

The liquid fatty acids are separated as described under Muter's method.[a] The liquid fatty acids are treated in a test tube with a mixture of 1 cc of a 5 per cent aqueous solution of silver nitrate and 10 cc of 90 per cent alcohol, and heated to from 70° to 80° for several hours if necessary, in order to get a reduction of silver. By this method small quantities of heated cotton-seed oil in olive oil may be detected. Other reactions which will show the presence of heated cotton-seed oil are the nitric-acid test, using acid of specific gravity 1.375, and the Brullé[b] test, with nitric acid and egg albumen. The former was tried on some heated cotton-seed oil which would not react with the Halphen reagent, and a strong reaction was obtained with a mixture of 10 per cent of heated cotton-seed oil and 90 per cent of olive oil. Smaller amounts could easily be detected. The test is not as sensitive as the Halphen or Bechi test on untreated oils, but it is of great value for use with heated oils. It may also be of value in determining whether a weak test with the Halphen reagent is due to a small amount of unheated cotton-seed oil or a larger amount which has been heated enough to weaken the Halphen reaction. Some of the other oils react, however, with nitric acid. Sunflower oil, treated by this method, gives a deep brown color which can not be distinguished from the color obtained with cotton-seed oil. Peanut oil gives only a very slight test. Maize oil reacts very strongly, giving a peculiar reddish color that might be mistaken at first for the cotton-seed oil test.

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 65, p. 28.

[b] R. Brullé, Comp. rend., 1893, 106: 1017.

The Brullé[a] test for cotton-seed oil is also effective on oils heated to 250° C. It is conducted as follows: Place in a test tube 0.1 gram of dry albumen finely powdered and 2 cc of nitric acid (3 parts nitric acid, 1.40 specific gravity and 1 part water) and 10 cc of oil. Heat without stirring until the acid begins to boil, then cautiously agitate until the albumen is dissolved. Under this treatment olive oil will not show any change of color, while cotton-seed oil can be detected by the red coloration. Other oils, such as peanut, sunflower, and rape, are also colored by this process. Olive oil forms an elaidin after this treatment, which is very different from that given by the other oils, except lard oil, which, because of its content of oleic acid, acts very similarly.

Peanut Oil.

Peanut oil is probably used as an adulterant of olive oil more extensively in Europe than in this country where cotton-seed oil is so common. The oil has a pleasant, nutty flavor, and makes a good salad oil, for which purpose it is quite extensively used in Europe under its own name. The values of peanut oil are so little different from olive oil that considerable quantities of it could be mixed with olive oil without being detected by these figures. Table XXIV gives the results compiled from published data on peanut oil.

Table XXIV.—*Peanut oil.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5°C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Perct.*
Müntz, Durand, and Milliau:[a]										
Minimum	0.9175			46.0	127.0	97.0	.....	31.0	28.0	.....
Maximum	.9210	.....	.....							
S. P. Sadtler:[b]										
Minimum	.9110	.....	.....	49.0	.....	85.6	190.6	29.0	25.0	0.54
Maximum	.9200	.....	.....	56.7	.....	95.0	194.0	34.0	32.0	.79
De Negri and Fabris:[c]										
Minimum	.9165	.....	.....	45.0	.....	92.0	189.4	27.0	22.0	.....
Maximum	.9200	.....	.....	51.0	.....	100.0	193.0	31.0	25.0	.....
Tolman and Munson:[d]										
Minimum	.9155	67.5	1.4707	46.5	129.1	87.8	188.8	33.2	.....	.24
Maximum	.9188	71.3	1.4731	63.2	154.2	96.3	191.8	36.4	.....	13.51
Twenty-one other analysts:[e]										
Minimum	.9160	.....	.....	44.0	.....	85.6	189.3	26.0	23.0	.....
Maximum	.9220	.....	.....	67.0	.....	105.0	196.0	35.0	31.0	.....
Maximum	.9220	.....	.....	67.0	154.2	105.0	196.0	36.4	32.0	13.51
Minimum	.9110	.....	.....	44.0	127.0	85.6	188.8	26.0	23.0	.24

[a] Bulletin du Ministère de l'Agriculture, 1895, p. 139.
[b] 4 samples. Amer. Druggist and Pharm. Rec., 1897, vol. 31, no. 5.
[c] 8 samples. Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 12.
[d] 5 samples.
[e] Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 12.

From this table it can be seen that oils could be selected for admixture which would not affect the values of olive oils to any degree except

[a] Chem. Ztg. Rep. 1888, 12: 107.

in case of very gross adulteration. Sample 499, Table XXXIII, a cold pressed oil prepared in this laboratory, is an example of this. It has a specific gravity of 0.9186, a Hübl number of 87.8 and 0.40 per cent of free acid. Such an oil could be mixed in almost any proportion with an olive oil of low iodin number and not give even a hint from the physical and chemical values of its presence. Practically the only test that is positive is the isolation of arachidic acid, which is present in peanut oil to the extent of from 3 to 5 per cent. In four samples of peanut oil examined in this laboratory from 3.41 to 4.24 per cent of the acid was found, having a melting point of from 72° to 73°. Allen[a] gives an average of 5 per cent. In Table XXXIII results are given on two samples of peanut oil, Nos. 13234 and 13235, which were examined to determine the effect of age. Both had been kept in stoppered bottles for eight years; No. 13235 was a heated oil. Both were exceedingly rancid to taste and smell, but No. 13234 had only 2.93 per cent of free acid, showing that acidity is not an index of rancidity. No. 13235 shows that great changes have been brought about in the oil in the process of heating.

Renard's[b] test is as satisfactory as any of the methods for detecting arachidic acid. Twenty grams of the oil to be tested should be taken so that enough of the arachidic acid can be separated to make the melting point which should be determined in every case, as some oils, such as cotton-seed and lard, will give a precipitate which resembles arachidic acid except that it has a lower melting point.

Sesame Oil.

Like peanut oil, sesame oil has a pleasant flavor and is well adapted to the adulteration of olive oil. However, it is not extensively used in this country, as the analyses of commercial samples show. Table XXV gives the results compiled from published data on sesame oil.

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[a] Com Org. Anal., 3d ed., vol. 2, pt. 1, p. 134.

[b] Comp. Rend. 1871, **73**: 1330. U. S. Dept. Agr., Bureau of Chemistry, Bul. 65, p. 33.

TABLE XXV.—*Sesame oil.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Perct.*
De Negri and Fabris:[a]										
Minimum	0.9230	.....	.....	63.0	.....	106.8	188.4	23.0	20.0	.....
Maximum	.9237	.....	.....	64.0	.....	107.7	190.4	26.0	22.0	.....
Tolman and Munson[b]	.9218	73.3	1.4742	61.3	170.3	97.9	190.7	27.4	.....	0.44
Müntz, Durand, and Milliau[c]	.9230	.....	.....	54.0	150.0	104.0	.....	26.0	22.0	.....
Twenty-five other analysts:[d]										
Minimum	.9200	.....	.....	65.0	.....	102.0	190.0	21.0	21.0	.....
Maximum	.9250	.....	.....	68.5	.....	112.0	194.6	40.0	34.0	.....

[a] 6 samples. Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 82.
[b] 1 sample.
[c] Bulletin du Ministère de l'Agriculture, 1895, p. 139.
[d] Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 82.

The specific gravity, index of refraction, Maumené number, and iodin number of this oil are all materially higher than for olive oil, and serve as an indication of adulteration. The qualitative test of Baudouin and Villavecchia's modification of the same, are characteristic of sesame oil and permit of the certain detection of amounts as small as 2 per cent. It must always be remembered, however, that there are some olive oils from Italy and Tunis which give a reaction with this test which is difficult to differentiate unless comparative tests are carried on with sesame oil, when they can be readily distinguished. Milliau[a] states that when the fatty acids were used in making this test on Tunis oils the red coloration found with the oils themselves was not obtained.

MAIZE OIL.

Maize oil is produced in large amounts in the United States, and, owing to its cheapness, may find use as a substitute for olive oil. This product, which is a semidrying oil similar to cotton-seed oil, has thus far been used but little for salad purposes, only one sample being found upon the market. It possesses the flavor and odor characteristic of maize, and these qualities aid in its detection when not mixed with other oils. The results of the analysis of a number of maize oils are given in Table XXVI.

[a] Milliau, Bertainchand, and Malet, Rapport sur les huiles d'olive de Tunisie, 1900, p. 33.

TABLE XXVI.—*Maize oil.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Per ct.*
De Negri and Fabris:[a]										
Minimum	0.9215	.....	.....	84.0	.....	111.1	190.0	17.0	13.0	.....
Maximum	.9220	.....	.....	86.0	.....	112.6	190.8	20.0	16.0	.....
Tolman and Munson:[b]										
Minimum	.9233	76.2	1.4760	75.2	190.2	116.7	189.9	21.6	.....	1.80
Maximum	.9253	77.5	1.4768	89.2	212.5	123.3	193.4	23.0	.....	3.60
Archbutt[c]	.9243	.....	.....	81.6	.....	122.7	189.7	.....	.....	2.40
Vulté and Gibson[d]	.9213	.....	1.4766	74.0	176.0	118.6	192.6	22.4	.....	1.12
Six other analysts:[e]										
Minimum	.9215	.....	.....	56.0	.....	119.6	188.0	16.0	13.0	3.12
Maximum	.9255	.....	.....	89.0	.....	123.9	193.4	20.0	14.0	3.50

[a] 3 samples. Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 122.
[b] 4 samples.
[c] Jour. Soc. Chem. Ind., 1899, **18**: 346.
[d] Jour. Amer. Chem. Soc., 1900, **22**: 453.
[e] Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 122.

The specific gravity, rise of temperature with sulphuric acid, index of refraction, and iodin absorption are much higher for maize than for olive oil, and the last three values are considerably higher than for cotton-seed oil. The high Maumené number and iodin absorption of this oil would materially influence the values of olive oil even when added in amounts as small as 10 or 15 per cent. The content of solid fatty acids of maize oil is rather low, hence the iodin number of the liquid fatty acids is not so characteristic as with cotton-seed oil. Maize oil gives a peculiar red color when shaken with nitric acid (specific gravity, 1.37), which is quite different from the color obtained with cotton-seed oil, and would serve to differentiate them.

MUSTARD-SEED OIL.

This oil belongs to the rape-seed oil group, and in general characteristics it differs but slightly from rape-seed oil, as is apparent from Table XXVII.

TABLE XXVII.—*Mustard-seed oil.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Per ct.*
De Negri and Fabris:[a]										
Minimum	0.9125	.....	.....	42.0	.....	92.1	170.2	15.0	.....	.....
Maximum	.9175	.....	.....	45.0	.....	106.5	174.6	18.0	.....	.....
Tolman and Munson:[b]										
Minimum	.9147	74.5	1.4750	61.4	130.9	98.4	173.0	20.8	.....	0.13
Maximum	.9193	76.5	1.4762	79.4	190.3	113.0	182.8	21.5	.....	1.13
Blasdale:[c]										
Minimum	.9151	.....	1.4751	.....	.....	98.4	173.9	15.0	.....	.....
Maximum	.9161	.....	1.4760	.....	.....	103.6	174.7	16.0	.....	.....
Crosseley and Le Sueur:[d]										
Minimum	.9142	}	1.4740	.....	.....	{ 96.8	171.2	.....	.....	1.36
Maximum	.9155	}		.....	.....	{ 98.8	173.3	.....	.....	1.85
Müntz, Durand and Milliau:[e]	.9180	.....	.....	39.0	108.0	96.0	.....	16.0	15.0	.....
Seven other analysts:[f]										
Minimum	.9142	}	.....	44.0	.....	96.0	.....	16.0	.....	.....
Maximum	.9183	}								

[a] 6 samples. Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 37.
[b] 5 samples.
[c] 2 samples. Jour. Amer. Chem. Soc., 1895, **17**: 935.
[d] 2 samples. Jour. Soc. Chem. Ind., 1898, **17**: 989.
[e] 1 sample. Bulletin du Ministère de l'Agriculture, 1895, p. 139.
[f] Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 37.

It is probable that this oil is seldom if ever used as an adulterant of olive oils, although it is frequently added to rape oil, and this may find its way into olive oil. Means of detecting it in small quantities are as unsatisfactory as for rape oil, and the analyst will scarcely be able to distinguish between the oils of this group.

The presence of sulphur compounds in the oils of the *Cruciferæ* gives a means for their detection. If the oils are saponified with alcoholic potash and stirred with a silver spatula, the silver will become blackened by the formation of sulphid.

RAPE-SEED AND COLZA OILS.

Rape-seed and colza oils may be considered practically identical as regards source and composition, and for convenience the terms are considered here as being synonymous. This oil is derived from various species of *Brassica* of the family *Cruciferæ*, and according to Allen[a] is used as an adulterant for olive oil. According to the Codex Alimentarius Austriacus rape oil or colza oil is the oil from the field cabbage (*Brassica campestris*), but all the following oils are sold under the name of rape oil: Colza oil from *Brassica campestris;* rape oil from *Brassica campestris*, variety *napus;* rape oil from *Brassica campestris*, variety *rapa;* Hederich oil from *Raphanus Raphanistrum* or field radish, and radish oil from *Raphanus sativus.* Although the

[a] Com. Org. Anal., 3d ed., vol. 2, pt. 1, p. 92.

values of this oil would make small additions of it difficult of detection, it is not so well adapted as a substitute for olive oil as the products previously mentioned under this class, owing to the acrid taste of even the well-refined oil. Analyses of rape and colza oils are given in Table XXVIII.

TABLE XXVIII.—*Rape-seed and colza oils.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification number.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Per ct.*
Crosseley and Le Sueur:[a]										
Minimum	0.9142		1.4744	.....	.....	94.1	167.7	.....	.....	0.36
Maximum	.9171					104.8	173.0	.....	.....	1.78
Tolman and Munson:[b]										
Minimum	.9143	74.1	1.4748	54.5	135.0	92.5	174.1	20.0	.....	.63
Maximum	.9163	74.8	1.4752	67.8	152.5	101.2	176.6	21.9	.....	3.57
Müntz, Durand, and Milliau:[c]										
Minimum	.9145	.....	.....	48.0	133.0	99.0	.....	15.5	15.0	.....
Maximum	.9150	.....	.....	56.0	155.0	103.0	.....	17.0	16.0	.....
De Negri and Fabris:[d]										
Minimum	.9150	.....	.....	49.0	.....	97.2	175.0	16.0	.....	.....
Maximum	.9170	.....	.....	51.0	.....	102.1	177.0	19.0	.....	.....
Twenty-one other analysts:[e]										
Minimum	.9112	.....	.....	50.0	.....	97.0	170.0	15.5	.....	.....
Maximum	.9184	.....	.....	59.0	.....	106.2	183.0	22.0	.....	.....

[a] 7 samples. Jour. Soc. Chem. Ind., 1898, **17**: 989.
[b] 4 samples.
[c] 2 samples. Bulletin du Ministère de l'Agriculture, 1895, p. 139.
[d] 14 samples. Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 26.
[e] Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 26.

The specific gravities of these oils are practically identical with that of the olive; the index of refraction, iodin number, and rise of temperature with sulphuric acid are considerably higher. The saponification number is much lower than for olive oil or for any of the oils used to adulterate it, with the exception of the other members of the rape-oil group. The average saponification value given for rape oil is about 173, while the average value for olive oil is about 193, and an olive oil having a saponification value much below 190 should be looked upon with suspicion. An addition of less than 20 per cent of rape oil would probably be difficult to detect, but this amount should be sufficient to materially affect the values of a normal olive oil. Low specific gravity accompanied by a high index of refraction is one of the marked characteristics of rape oil, wherein it differs from most oils which with a low specific gravity have a low refractive index.

Valenta[a] has suggested the differentiation of oils by their solubility in glacial acetic acid of 1.0562 specific gravity, and states that rape and mustard oils are the only common oils not completely soluble in this

[a] Dingler, 1884, **252**: 296; Jour. Chem. Soc., 1884, **46**: 1078.

acid. Allen[a] confirms the statement of Valenta, but suggests that the solubility of an oil is greatly increased by a high percentage of free acids. The strength of acetic acid used, according to this author, may vary considerably without greatly affecting the solubility. Hurst,[b] on the other hand, finds that rape and colza oils are completely dissolved by glacial acetic acid and gives the temperature turbidity of from 73° to 99°. Thomson and Ballantyne[c] have also studied this question and find that Valenta's statement holds good only when acetic acid of specific gravity 1.0562 is employed; if an acid of specific gravity 1.0542 is used rape oil is completely soluble.

In working in this laboratory upon Valenta's test with acid of 99.5 per cent strength it was found that rape oil and mustard oil both dissolve completely at a temperature of 120° C., although at a very slightly reduced temperature the oils are again partly precipitated. Olive oil is readily soluble at 120°, but precipitates again upon a slight reduction of temperature. Mixtures composed of 20 per cent and 40 per cent of rape oil with olive oil and similar mixtures of mustard oil showed no distinction from pure olive oil in respect to solubility. Hence as a means of detecting rape oil, and especially mixtures of the same with olive oils, this test must be considered of little value.

Sunflower Oil.

Sunflower oil has a mild taste and pleasant odor, and the cold drawn oil is said to be used in some sections of Europe for culinary purposes.[d] The physical and chemical characteristics of this oil are so widely different from those of olive oil that additions of even relatively small amounts to olive oil would be sufficient to make the values of the latter abnormal. The compiled results of the analyses of sunflower oil are given in Table XXIX.

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[a] Jour. Soc. Chem. Ind., 1886, **5**: 69, 282.
[b] Jour. Soc. Chem. Ind., 1887, **6**: 22.
[c] Jour. Soc. Chem. Ind., 1891, **10**: 233.
[d] Jour. Soc. Chem. Ind., 1892, **11**: p. 470.

TABLE XXIX.—*Sunflower oil.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Per ct.*
De Negri and Fabris:[a]										
Minimum	0.9260	.....	.....	72.0	.....	119.7	188.0	22.0	18.0	.....
Maximum		.....	.....	75.0	.....	120.1	189.3	24.0		.....
Tolman and Munson:[b]										
Minimum	.9201	72.1	1.4736	60.0	167.0	104.1	191.2	21.0	.....	0.18
Maximum	.9205	72.7	1.4739			108.3	192.3			1.72
Lewkowitsch:[c]										
Minimum	.9240	.....	1.4769	67.5	.....	119.7	188.0	23.0	17.0	.....
Maximum	.9262	.....		73.0	.....	135.0	194.0			.....
Allen:[d]										
Minimum	.9240	.....	.....	.....	.....	122.0	188.4	.....	.....	.....
Maximum	.9260	.....	.....	.....	.....	135.0	197.6	.....	.....	.....
Seven other analysts:										
Minimum	.9260	.....	.....	.....	.....	129.0	192.0	17.0	.....	.....
Maximum	.9520	.....	.....	.....	.....	133.2	194.0	23.0	.....	.....

[a] 3 samples. Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 106.
[b] 2 samples.
[c] Oils, Fats, and Waxes, p. 356.
[d] Com. Org. Anal., 3d ed., vol 2, pt. 1, p. 93.

POPPY-SEED OIL.

According to Allen[a] and Lewkowitsch,[b] this oil is quite largely used in Europe as a salad oil and for culinary purposes, and is used somewhat as an adulterant for olive oil. In this country, however, it is not used either as a salad or cooking oil to any extent, and it is doubtful whether it is ever used as an olive-oil adulterant. From Table XXX it is seen that the specific gravity, index of refraction, Maumené number, and iodin absorption of poppy oil are exceptionally high, and these characteristics are sufficient to indicate its addition to an olive oil, although, in the absence of distinct qualitative tests, the difficulty of definitely distinguishing between this oil and some of the others already mentioned, when added in small proportions, is apparent.

[a] Com. Org. Anal., 3d ed., vol. 2, pt. 1, p. 94.
[b] Oils, Fats, and Waxes, 2d ed., p. 352.

TABLE XXX.—*Poppy-seed oil.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Per ct.*
De Negri and Fabris: *a*										
Minimum	0.9270			88.5	136.8	.....	193.4	20.0	.....	.....
Maximum		.....	.....		137.5	.....	193.8	21.0	.....	.....
Tolman and Munson: *b*										
Minimum	.9239	77.1	1.4766	75.8	213.0	133.2	190.2	25.4	.....	0.90
Maximum	.9244	77.8	1.4770	85.5	237.5	134.9	193.8	25.8	.....	2.31
Müntz, Durand, and Milliau *c*	.9250	.....	.....	80.0	222.0	133.0	.....	20.5	16.0	.....
Sixteen other analysts:										
Minimum	.9240	.....	.....	71.0	.....	130.5	192.8	20.5	.....	.....
Maximum	.9370	.....	.....	86.4	.....	141.0	194.0			

a 3 samples. Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 114.
b 2 samples.
c 1 sample. Bulletin du Ministère de l'Agriculture, 1895, p. 139.

LARD OIL.

This oil is so manufactured that it remains liquid at ordinary temperatures, and when well refined is entirely free from the taste and odor of lard. When heated, however, this odor is developed, and may serve as a means of distinguishing lard oil when not mixed with other oils. If so mixed, however, even though the lard oil be largely in excess, this odor is sufficiently masked to make the test of little value. The following table gives a number of analyses of lard oil:

TABLE XXXI.—*Lard oil.*

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Per ct.*
Tolman and Munson: *a*										
Minimum	0.9148	66.8	1.4702	39.9	103.3	69.7	195.3	33.2	.....	0.28
Maximum	.9175	69.5	1.4720	47.8	110.8	77.2	197.7	38.4	.....	1.28
Duyk: *b*										
Minimum	.9154	65.2	1.4692	.....	.....	73.0	193.0	35.0	31.0	.....
Maximum										
Allen: *c*										
Minimum	.9150	.....	.....	41.0	.....	67.0	189.5	.....	.....	.....
Maximum						82.0	196.0			
Müntz, Durand, and Milliau: *d*										
Minimum	.9160	.....	.....	33.0	91.0	60.0	.....	35.0	34.0	.....
Maximum										

a 4 samples.
b Bulletin de l'Association Belge, 1901, 15:18.
c Com. Org. Anal., 3d ed., vol. 2, pt. 1, p. 98.
d Bulletin du Ministère de l'Agriculture, 1895, p. 139.

The specific gravity, refractive index, rise of temperature with sulphuric acid, and saponification number of this oil are practically identical with the same values of olive oils. The iodin number is much lower, and the melting point of fatty acids much higher than for olive oils, but when mixed, for example, with an olive oil having a high iodin number and a consequently low melting point for its fatty acids as much as 50 to 60 per cent of the lard oil could be used without rendering these values abnormal for pure oils. The lard oils have a high content of solid fatty acids, but this factor is rendered of little value when the oil is mixed with an olive oil having a high iodin number, since such an olive oil will probably have a correspondingly low content of solid fatty acids as is shown by Table XXXIII.

Miscellaneous Oils.

The oils named in tables XXXII and XXXIII were analyzed to obtain further data regarding their values, and also for the purpose of studying their use in the adulteration of olive oil. Through the kindness of the V. D. Anderson Company, of Cleveland, a number of cold-pressed oils were prepared from seeds which were identified in the seed laboratory of the Department of Agriculture. They are as follows:

Brown mustard	*Brassica arvensis* (charlock).
Black mustard	*Brassica juncea* (Indian mustard).
Yellow mustard	*Sinapis alba* (yellow mustard).
Rape	*Brassica napus.*
Poppy	*Papaver somnifera* (opium poppy).

The cocoanut oil was pressed from the flesh of cocoanuts. The peanuts used were from Virginia. The almond, cotton-seed, and linseed oils were prepared from commercial seed. Other oils were prepared in the laboratory.

There are a number of commercial oils included in these tables, but as there was no way of being assured of their purity the results obtained are not of great value. Sample No. 23606 was sent by Armour & Co. as a pure neutral lard oil and it had practically no lard odor or taste except when heated. These samples were discussed under the headings of the various oils.

Table XXXII.—*Description of miscellaneous oils.*

Serial No.	Kind of oil.	Source.	Description.
22077	Cocoanut	India Refining Co., Philadelphia, Pa.	Konut—cocoanut oil, lard substitute.
773	do	V. D. Anderson Co., Cleveland, Ohio.	Cold-drawn oil.
494	Palm	Schiefflein & Co., New York City	Commercial oil.
22433	Lard	Armour & Co., Chicago, Ill.	Prime lard oil.
22434	do	Z. D. Gilman, Washington, D. C.	
23606	do	Armour & Co., Chicago, Ill.	Neutral lard oil.
487	do	Schiefflein & Co., New York City	Commercial oil.
1181	Magnolia	James Brody, Biloxi, Miss.	Oil from pulp of magnolia seed.
1182	do	do	Fat from pulp of magnolia seed.
1150	do	do	Oil from pulp of magnolia seed.

TABLE XXXII.—*Description of miscellaneous oils*—Continued.

Serial No.	Kind of oil.	Source.	Description.
23656	Peanut	Z. D. Gilman, Washington, D. C.	Commercial oil.
499	do	Prepared in laboratory.	Cold-drawn oil.
13234	do		8 years old.
13235	do		8 years old; cooked oil.
772	do	V. D. Anderson Co., Cleveland, Ohio.	Cold-drawn oil.
1149	do	A. E. Leach, Boston, Mass.	
486	Mustard	Schiefflein & Co., New York City.	Commercial oil.
495	do	Prepared in laboratory.	Cold-drawn oil; black mustard.
770	do	V. D. Anderson Co., Cleveland, Ohio.	Cold-drawn oil; brown mustard.
771	do	do	Cold-drawn oil; black mustard.
776	do	do	Cold-drawn oil; yellow mustard.
490	Rape	Schiefflein & Co., New York City.	Commercial oil.
496	do	Prepared in laboratory.	Cold-drawn oil.
775	do	V. D. Anderson Co., Cleveland, Ohio.	Do.
937	do	V. Villavecchia, Rome, Italy.	Colza oil di Vercelli (Picimente).
1187	Almond	V. D. Anderson Co., Cleveland, Ohio.	Cold-drawn oil.
489	Sesame	Schiefflein & Co., New York City.	Commercial oil.
23624	Sunflower	Prepared in laboratory.	Cold-drawn oil.
498	do	do	Do.
491	Maize	Schiefflein & Co., New York City.	Commercial oil.
444	do	Glucose Sugar Refining Co., Chicago, Ill.	
497	do	Indianapolis Hominy Mills, Indiana.	Do.
777	do	V. D. Anderson Co., Cleveland, Ohio.	Cold-drawn oil.
1159	Cotton-seed	American Cotton Oil Co., New York City.	Commercial oil—"Butter Oil."
1160	do	do	Commercial oil—"Summer White."
1161	do	do	Commercial oil—"Cooking Oil."
1186	do	V. D. Anderson Co., Cleveland, Ohio.	Cold-drawn oil.
493	Poppy	Schiefflein & Co., New York City.	
774	do	V. D. Anderson Co., Cleveland, Ohio.	Do.
1188	Linseed	do	Do.

TABLE XXXIII.—*Analyses of miscellaneous oils.*

COCOANUT OIL.

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification value.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								°C.	*Per ct.*	*Per ct.*
22077	0.9269	.....	.....	.....	.....	7.90	.....	.....	.....	.....	.....	.....
773	.9259	49.1	1.4587	21.0	44.0	8.58	31.9	.....	259.5	25.2	65.90	0.11

PALM OIL.

494	0.9128	.....	.....	.....	.....	53.0	99.0	.....	201.0	49.2	.....	19.53

LARD OIL.

22433	0.9148	67.4	1.4706	47.8	106.2	75.9	94.0	98.9	195.7	33.2	18.90	0.75
23434	.9145	67.4	1.4706	46.8	104.0	77.2	.....	101.3	195.3	34.2	19.30	.78
23606	.9160	69.5	1.4720	46.5	103.3	69.7	95.8	101.3	197.7	38.4	26.68	.28
487	.9175	66.8	1.4702	39.9	110.8	72.5	93.9	97.9	196.2	35.8	21.43	1.28

MAGNOLIA OIL.

1181	0.9128	64.5	.....	.....	.....	81.7	.....	106.2	189.5	34.3	18.32	38.07
1182	.....	.....	.....	.....	.....	76.1	.....	106.7	189.2	38.2	24.24	48.28
1150	.9130	65.0	.....	.....	.....	80.4	.....	100.3	.....	.....	15.48	.....

TABLE XXXIII.—*Analyses of miscellaneous oils*—Continued.

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification value.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								°C.	*Per ct.*	*Per ct.*
23656	0.9155	67.5	1.4707	61.0	135.5	89.1	.....	.....	191.4	33.2	.....	13.51
499	.9186	70.0	1.4723	46.5	129.1	87.8	.....	.....	191.8	34.3	.....	*a* .40
13234	.9188	71.0	1.4729	55.5	154.2	93.4	.....	.....	190.7	36.0	.....	*b* 2.93
e 13235	.9364	75.0	1.4753	67.3	186.9	77.0	.....	.....	199.0	37.6	.....	*c* 5.96
772	.9188	71.3	1.4731	63.2	135.3	96.3	114.6	.....	189.9	36.4	.....	*d* .24
1149	.....	70.5	1.4726	.....	.....	94.3	.....	.....	188.8	33.6	.....	.....
MUSTARD OIL.												
486	0.9178	76.1	1.4759	68.5	190.3	103.0	.....	.....	175.9	21.0	.....	1.13
495	.9170	76.5	1.4762	68.2	189.4	105.8	.....	115.7	176.0	21.5	4.05	.38
770	.9184	76.2	1.4760	77.6	165.4	110.4	114.2	116.8	178.5	20.8	1.06	.48
771	.9193	76.5	1.4762	79.4	169.3	113.0	119.8	121.1	182.8	20.8	2.32	.34
776	.9147	74.5	1.4750	61.4	130.9	98.4	103.1	103.0	173.0	21.1	Trace.	.13
RAPE OIL.												
490	0.9161	74.3	1.4749	54.5	151.4	92.5	100.5	96.9	175.7	20.0	0.12	3.57
496	.9143	74.3	1.4749	54.9	152.5	92.7	101.5	98.0	174.7	21.9	1.02	.63
775	.9163	74.1	1.4748	63.6	135.6	101.3	105.1	106.0	176.6	20.5	Trace.	1.26
937	.9158	74.8	1.4752	67.8	144.5	101.2	.....	107.5	174.1	20.4	1.43	1.52
ALMOND OIL.												
1187	0.9186	70.9	.....	45.3	117.6	96.2	.....	.....	192.5	23.2	.....	0.48
SESAME OIL.												
489	0.9218	73.3	1.4742	61.3	170.3	106.6	.....	115.4	190.7	27.4	10.70	0.44
SUNFLOWER OIL.												
23624	0.9201	72.7	1.4739	.....	.....	108.3	113.8	117.8	192.3	21.0	3.67	0.18
498	.9205	72.1	1.4736	60.0	166.7	104.1	105.3	113.8	191.2	21.0	4.12	1.72
MAIZE OIL.												
491	0.9233	76.2	1.4760	75.2	208.9	119.2	133.3	134.5	193.4	22.0	6.98	3.12
444	.9256	77.3	1.4767	76.5	212.5	119.7	126.6	134.8	191.5	23.0	6.70	1.80
497	.....	75.6	1.4757	.....	.....	116.7	129.4	132.1	191.7	.....	7.07	.....
777	.9253	77.5	1.4768	89.2	190.2	123.3	134.5	139.8	189.9	21.6	7.44	3.66
COTTON-SEED OIL.												
1159	0.9226	72.5	1.4738	66.4	172.9	103.8	.....	.....	197.1	35.5	22.90	0.07
1160	.9226	72.3	1.4737	73.4	191.1	106.2	.....	.....	196.9	39.0	22.43	.07
1161	.9226	72.3	1.4737	66.2	172.4	104.8	.....	.....	196.0	39.6	23.60	.04
1186	.9236	75.6	1.4757	67.1	174.3	110.9	.....	.....	198.5	38.0	.....	2.17

a 3.41 per cent arachidic acid; melting point 72.5°; cold pressed oil.
b 3.78 per cent arachidic acid; melting point 72.5°.
c 4.24 per cent arachidic acid; melting point 73°.
d 4.12 per cent arachidic acid; melting point 72°; cold pressed oil.
* Cooked oil.

TABLE XXXIII.—*Analyses of miscellaneous oils*—Continued.

POPPY OIL.

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification value.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								°C.	*Per. ct.*	*Per ct.*
493	0.9239	77.1	1.4766	85.5	237.5	133.2	.....	.....	190.2	25.4	.....	2.31
774	.9244	77.8	1.4770	75.8	213.0	134.9	142.0	151.7	193.8	25.8	6.67	.90

LINSEED OIL.

1188	0.9318	88.8	1.4831	.....	.....	179.5	.....	.....	191.7	19.2	3.88	0.40

OLIVE OILS OF KNOWN ORIGIN.

CALIFORNIA OILS.

The oils in Tables XXXIV and XXXV were obtained principally from producers of established reputations and were accompanied by affidavits as to purity. Three samples, made at the station, were obtained from G. E. Colby, of the California Agricultural Experiment Station. The oils reported on are from all parts of the State devoted to olive culture and represent practically all the different existing soils and climatic conditions, which undoubtedly exert a great influence on the chemical and physical characteristics of the samples.

The results give a good idea of the variability of California oils. The analyses are more complete than any previously published data on this subject, which gives them added value in determining the limits of the various values. The per cent of free fatty acids eliminates two oils which would otherwise give an extraordinary variation to the specific gravity and index of refraction figures, a variation that is certainly not legitimate for the grade of oils considered here. Oils such as Nos. 22619 and 673 are not fit for use as salad oils, as they contain 44 and 12 per cent of free acid respectively. This factor should always be taken into consideration in reporting low results on specific gravity and refractive index. The variety of olive and the climate and soil may greatly affect the oil; how much these factors affect the product must be decided by further study. Six samples of oil (Nos. 23456, 831, 833, 23457, 832, and 834) show the uniformity of oils produced from different varieties of olive where the soil and climatic conditions are the same and the same process of manufacture is used. The first three were made from Italian varieties and the last three from the Mission olive. The Mission olive, introduced into California by the old Mission fathers, is the variety generally grown in the State, and most of the oil made comes from it. Table XXXVI gives the compiled results of analyses of California oils.

TABLE XXXIV.—*Description of California olive oils of known origin.*

Serial No.	Source.	Description.
23692	John Bidwell estate, Chico	"Rancho Chico" pure olive oil; made from Mission olives.
23463	Fred Busby, Concord	Pure olive oil from Busby's olive grove; made from Mission olives.
22617	G. E. Colby, Berkeley	Oil from Redding Picholine olives; made in 1893.
22618	do	Oil from mixed varieties; made in 1898.
22619	do	Oil from Manzanillo olives (poor quality); made in 1900.
22713	Elwood Cooper, Santa Barbara	Highest grade olive oil; made from Mission olives.
22714	do	Second pressing olive oil, 10 years old; made from Mission olives.
22715	do	Common grade olive oil (for lubricating and similar purposes); made from Mission olives.
23458	do	Pure olive oil, highest grade; made from Mission olives.
23649	Ehmann Olive Co., Oroville	Pure olive oil.
844	do	Do.
838	C. M. Gifford, San Diego	"Gifford's Best" olive oil; made from Mission olives.
839	do	Olive oil just from separator; made from Mission olives.
840	do	Olive oil 6 weeks old; made from Mission olives.
23456	Edward E. Goodrich, Santa Clara	El Quito olive oil, Italian variety.
831	do	El Quito olive oil, Italian variety, 1901.
833	do	El Quito olive oil, Italian variety, 1902.
23457	do	El Quito olive oil, Mission variety.
832	do	El Quito olive oil, Mission variety, 1901.
834	do	El Quito olive oil, Mission variety, 1902.
23462	J. C. Gray, Oroville	Pure olive oil from Mount Ida olive grove; made from Picholine olives.
506	James Hill & Sons, Los Angeles	Hill's pure olive oil.
836	do	Hill's pure olive oil; season 1901.
837	do	Olive oil, first pressing, 1902.
835	do	Olive oil, second pressing, 1902.
1091	J. A. Kleiser, Cloverdale	Pure olive oil.
23605	Peveril Meigs, Santa Barbara	Meigs's pure olive oil; made from Mission olives.
798	do	Olive oil; made from Mission olives.
795	do	Olive oil; sample taken from top of barrel.
796	do	Olive oil; sample taken from middle of barrel.
797	do	Olive oil; sample taken from bottom of barrel.
23460	Morris & Smith, Yolo	Pure olive oil.
23461	Dr. Prosek, Guerneville	Do.
23124	J. O. Riddell, Redlands	Riddell's pure olive oil.
841	do	Oil from ripe olives, 1901.
842	do	Oil from ripe olives, 1902.
843	do	Oil from green olives, 1902.
23459	Vincent C. Smith, Napa	Pure olive oil; from "Glen Olive" farm.
673	do	Second pressing olive oil; from "Glen Olive" farm.

TABLE XXXV.—*Analyses of California olive oils of known origin.*

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification value.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								° *C.*	*Per ct.*	*Per ct.*
23692	0.9168	68.5	1.4713	.....	.....	85.6	96.6	94.3	191.2	22.6	5.12	0.95
23463	.9164	68.4	1.4712	48.0	106.6	85.6	91.5	94.4	191.9	21.3	4.92	.79
22617	.....	67.3	1.4706	.....	.....	78.5	.....	.....	194.4	30.2	.....	.36
22618	.....	67.5	1.4707	.....	.....	83.7	.....	.....	192.5	20.7	.....	8.21
22619[a]	.....	62.0	1.4672	.....	.....	79.6	.....	.....	191.8	24.5	.....	44.40
22713	.....	68.7	1.4715	.....	.....	85.3	94.9	94.3	191.1	22.4	5.11	.73
22714	.....	68.5	1.4713	.....	.....	84.6	.....	92.2	191.5	22.4	3.87	1.26
22715	.....	68.2	1.4711	.....	.....	84.7	.....	90.5	191.3	20.5	2.02	2.73
23458	.9169	68.7	1.4715	48.4	107.5	88.2	94.9	96.8	191.4	23.5	4.42	.73
23649	.9164	68.0	1.4710	43.5	96.6	83.4	88.9	.....	192.1	22.6	.....	1.43
844	.9180	68.5	1.4713	46.9	97.9	84.2	.....	.....	189.7	25.8	.....	.35
838	.9169	69.2	1.4718	49.5	108.5	86.2	.....	96.4	190.6	24.0	6.15	1.07
839	.9171	69.2	1.4718	48.4	106.0	89.0	.....	98.2	189.9	21.2	4.94	3.51
840	.9169	68.9	1.4716	48.2	105.7	86.3	.....	96.3	189.4	24.0	5.94	1.09
23456	.9169	68.3	1.4711	47.7	106.0	84.3	93.4	95.4	191.9	23.4	7.23	.53
831	.9168	68.8	1.4715	46.6	98.1	85.2	.....	.....	189.3	20.6	.....	.61
833	.9170	68.8	1.4715	48.0	101.0	84.8	.....	95.2	189.8	20.2	6.55	.65
23457	.9166	68.3	1.4711	47.0	104.4	86.2	91.2	93.5	191.6	21.1	3.39	.97
832	.9173	68.8	1.4715	47.6	100.1	84.9	.....	93.2	189.3	20.5	5.40	.85
834	.9168	68.8	1.4715	46.2	97.2	84.5	.....	94.4	189.3	19.4	6.03	.34

[a] Not included in average on account of high percentage of free acid.

TABLE XXXV.—*Analyses of California olive oils of known origin*—Continued.

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification value.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								° *C.*	*Per ct.*	*Per ct.*
23462	.9162	66.9	1.4703	43.0	95.5	79.9	91.7	94.4	192.2	31.0	10.91	.79
506	.9174	68.5	1.4713	38.0	98.9	84.4	.....	.....	193.1	22.4	.....	.71
836	.9174	68.8	1.4715	48.2	105.7	86.0	.....	.....	190.7	24.8	.....	2.51
837	.9167	68.4	1.4713	45.0	98.6	84.2	.....	93.1	190.3	23.6	5.16	.51
835	.9167	68.2	1.4711	44.8	98.2	82.7	.....	92.6	190.4	26.0	6.19	.96
1091	.9167	68.8	1.4715	45.3	94.5	81.9	.....	.....	190.0	26.6	12.96	1.42
23605	.9171	68.5	1.4713	47.1	104.2	88.5	94.5	95.0	191.5	20.2	2.43	1.54
798	.9177	68.8	1.4715	51.0	107.3	89.7	.....	.....	190.0	19.2	.....	.63
795	.9177	69.0	1.4717	50.0	105.2	89.7	.....	98.7	189.8	19.8	4.73	.75
796	.9177	68.8	1.4715	52.1	109.7	89.8	.....	98.8	189.9	19.2	4.69	.61
797	.9177	68.8	1.4715	50.2	105.6	89.8	.....	98.6	189.7	19.6	5.44	.63
23460	.9167	68.2	1.4711	47.0	104.0	85.7	93.8	95.8	190.4	23.4	6.24	2.24
23461	.9162	67.5	1.4707	45.0	100.0	83.0	92.4	95.4	192.0	28.0	7.62	1.07
23124	.9171	68.2	1.4711	45.5	.....	83.7	92.5	93.7	193.3	25.4	6.20	.47
841	.9168	68.8	1.4715	47.1	98.3	86.9	.....	.....	189.4	21.6	8.61	.20
842	.9168	68.7	1.4715	46.8	97.7	87.2	.....	.....	189.5	21.4	7.52	.21
843	.9169	68.6	1.4714	45.6	95.2	85.1	.....	.....	189.6	22.8	4.33	.28
23459	.9162	67.7	1.4709	45.5	101.2	82.9	90.3	93.3	191.6	25.0	5.69	1.72
673[a]	.9149	66.4	1.4699	45.5	95.0	83.3	.....	.....	189.5	21.6	7.58	12.11
Average	.9170	68.4	1.4713	46.9	101.8	85.3	92.8	95.0	190.9	22.9	5.86	1.20
Max	.9180	69.2	1.4718	52.1	109.7	89.8	96.6	98.8	194.4	31.0	12.96	44.40
Min	.9162	62.0	1.4703	38.0	94.5	78.5	88.9	90.5	189.3	19.2	2.02	.20

[a] Not included in average on account of high percentage of free acid.

TABLE XXXVI.—*Analyses of California olive oils.* (Compiled.)

Analysts.	Determinations.								
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Free fatty acids as Oleic.
		Degrees.						° *C.*	*Perct.*
Blasdale:[a]									
Minimum	0.9161	.....	1.4710	45.0	.....	80.0	190.5	21.0	.....
Maximum	.9174	.....	1.4716	47.0	.....	86.5	193.5	26.0	.....
Tolman and Munson:[b]									
Minimum	.9162	66.9	1.4703	38.0	94.5	78.5	189.3	19.2	0.20
Maximum	.9180	69.2	1.4718	52.1	109.7	89.9	194.6	31.0	44.40
Colby:[c]									
Minimum	.9140	.....	1.4689	.....	.....	77.7	187.0	21.0	.....
Maximum	.9185	.....	1.4717	.....	.....	93.5	193.5	26.0	.....

[a] 11 samples. Jour. Amer. Chem. Soc., 1895, 17: 935.
[b] 42 samples.
[c] California Agr. Expt. Sta. Rept., 1897-98, p. 165.

ITALIAN OLIVE OILS.

These oils, results upon which are given in Tables XXXVII and XXXVIII, were obtained through V. Villavecchia, chemist of the custom-house at Rome, and Giacomo Dellapiane fu Andrea, of Genoa. The oils represent all the large oil-producing districts of Italy. It is impossible to give the variety of olive used on account of the great number of varieties in Italy; each small district may have a distinct variety of olives. The Italian olive oils are not materially different

from the California oils. They have a somewhat lower Hübl number, and the percentage of solid fatty acids and the melting point of the free fatty acids are on the average considerably higher. One noticeable difference between the two oils was observed after they had stood in an ice box for several weeks. Many of the California oils showed no separation of solid fats and none of them became solid, while nearly all the Italian oils did become solid. This characteristic also held with the commercial oils. The French oils resembled in this respect the Italian oils. Tables XXXIX and XL give the compiled results of analyses of Italian and miscellaneous olive oils, respectively.

TABLE XXXVII.—*Description of Italian olive oils of known origin.*

Serial No.	Source.	Description.
580	Fred Baller & Co., Messina	Pure olive oil (Bari).
933	V. Villavecchia, Rome	Olio di oliva di Bari (Puglie).
960	Giacomo Dellepiane fu Andrea, Genoa.	Bari, first quality.
961	do	Bitonto.
935	V. Villavecchia, Rome	Olio di oliva di Bitonto (Puglie).
936	do	Olio di oliva di Monopoli (Puglie).
962	Giacomo Dellepiane fu Andrea, Genoa.	Molfetta, Bari.
931	V. Villavecchia, Rome	Olio di oliva di Toscana.
932	do	Finest sublime Lucca oil, S. Rae & Co.
958	Giacomo Dellepiane fu Andrea, Genoa.	Lucca (Toscane); Lucca, first grade.
959	do	Lucca (Toscane); Lucca, second grade.
934	V. Villavecchia, Rome	Olio di oliva di Liguria (Genoa).
952	Giacomo Dellepiane fu Andrea, Genoa.	Maurizio (Liguria), Monte della Grasia
953	do	Genoa (Liguria), Spezia.
954	do	Genoa (Liguria), Genoa.
955	do	Olio fino, Genoa (Liguria), Loano.
957	do	Olio superfine, Genoa (Liguria), Loano.
956	do	Abruzzo, Fossacesia.

TABLE XXXVIII.—*Analyses of Italian olive oils of known origin.*

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification value.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								°C.	*Pr. ct.*	*Pr. ct.*
580	0.9177	67.9	1.4709	39.6	103.1	81.8	.....	.....	191.7	28.5	.....	.....
933	.9158	67.7	1.4708	43.5	95.6	80.4	94.8	101.8	192.0	26.2	16.47	1.02
960	.9159	67.6	1.4707	44.7	101.8	80.9	96.0	102.9	191.4	26.6	16.87	.80
961	.9162	67.6	1.4707	43.5	95.6	80.8	96.5	98.7	191.7	27.3	13.67	.69
935	.9162	67.7	1.4708	44.2	97.1	80.5	95.1	100.3	191.9	29.3	15.20	1.03
936	.9155	67.7	1.4708	44.8	98.4	81.8	96.2	96.8	191.5	26.2	11.07	2.79
962	.9159	67.6	1.4707	43.5	99.1	81.2	96.5	104.1	191.8	27.9	17.72	.62
931	.9166	67.6	1.4708	44.4	97.4	80.7	89.8	89.1	189.6	25.8	5.01	.82
932	.9167	67.5	1.4707	44.4	97.4	80.5	.....	.....	190.1	25.2	8.07	.80
958	.9158	68.0	1.4710	48.0	102.3	81.8	90.6	91.4	190.4	22.9	6.04	.79
959	.9164	68.0	1.4710	46.2	98.4	81.5	92.0	93.0	190.5	23.9	7.95	.63
934	.9159	67.6	1.4707	42.5	96.8	81.1	92.4	93.2	190.6	24.5	8.60	.92
952	.9160	68.0	1.4710	45.0	97.9	81.4	90.5	92.2	190.1	21.6	7.38	.61
953	.9161	67.3	1.4705	47.0	100.0	79.2	90.8	92.2	191.3	24.9	9.76	1.18
954	.9180	68.5	1.4713	48.3	103.0	86.1	97.5	98.0	190.5	25.0	7.76	2.55
955	.9157	67.8	1.4709	44.2	97.1	82.6	94.8	95.3	190.8	23.5	8.93	1.09
957	.9166	68.0	1.4710	45.0	97.9	82.1	91.1	91.2	189.7	21.6	5.53	1.90
956	.9164	68.3	1.4712	49.1	104.7	84.5	98.4	103.1	190.7	28.5	13.51	.57
Average	.9163	67.8	1.4709	44.9	99.1	81.6	94.0	96.5	190.9	25.5	10.50	1.11
Maximum	.9180	68.5	1.4713	49.1	104.7	86.1	98.4	104.1	192.0	29.3	17.72	2.79
Minimum	.9155	67.3	1.4705	39.6	95.6	79.2	89.8	89.1	189.6	21.6	5.01	.57

TABLE XXXIX.—*Italian olive oils.* (*Compiled.*)

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Pr. ct.*
De Negri and Fabris:[a]										
Minimum	[b]0.9160	.....	.....	32.0	.....	79.1	187.9	.....	.....	.....
Maximum	.9180	.....	.....	36.5	.....	88.3	192.2	.....	.....	.....
De Negri and Fabris:[a]										
Minimum	[c].9145	.....	.....	33.0	.....	81.1	185.0	.....	.....	.....
Maximum	.9178	.....	.....	36.5	.....	89.8	192.0	.....	.....	.....
De Negri and Fabris:[a]										
Minimum	[d].9160	.....	.....	32.0	.....	79.0	188.8	.....	.....	.....
Maximum	.9180	.....	.....	37.0	.....	87.1	192.3	.....	.....	.....
Average	.9166	.....	.....	.....	.....	83.7	.....	.....	.....	.....
Müntz, Durand and Milliau:[e]										
Minimum	.9158	.....	.....	30.0	83.3	83.7	.....	24.0	22.0	.....
Maximum	.9163	.....	.....	35.0	97.2	84.0	.....	24.5	23.0	.....
Tortelli and Ruggeri[f]	.9169	.....	.....	37.0	.....	.....	.....	23.7	.....	.....
Tolman and Munson:[g]										
Minimum	.9155	67.3	1.4703	39.6	95.6	79.2	189.7	21.6	.....	0.61
Maximum	.9180	68.5	1.4713	49.1	104.7	86.1	192.0	29.3	.....	2.79
Maximum	.9180	.....	.....	.....	104.7	89.8	192.0	29.3	.....	.....
Minimum	.9145	.....	.....	.....	83.3	79.0	185.0	24.0	.....	.....

[a] Annali del Laboratorio chimico centrale delle Gabelle, vol. 2, Gli Olii, pt. 2, p. 114.
[b] 18 samples. Oil from green olives.
[c] 17 samples. Oil from ripe olives.
[d] 53 samples. Pure oils from various sources.
[e] 4 samples. Bulletin du Ministère de l'Agriculture, 1895.
[f] Annali del Laboratorio chimico centrale delle Gabelle, 1900, vol. 4, p. 249.
[g] 18 samples.

TABLE XL.—*Miscellaneous olive oils.* (*Compiled.*)

Analysts.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Per ct.*
Müntz, Durand and Milliau (oils from Africa):[a]										
Minimum	0.9169	.....	.....	30.0	83.3	84.1	.....	24.0	22.5	.....
Maximum	.9172	.....	.....	35.0	97.2	84.5	.....	26.0	24.5	.....
Müntz, Durand and Milliau (oils from Spain):[b]										
Minimum Maximum	.9160	.....	.....	30.0 35.0	83.3 97.2	83.8	.....	24.0	22.0	.....
Müntz, Durand and Milliau (oils from Portugal):[b]										
Minimum Maximum	.9167	.....	.....	30.0 35.0	83.3 97.2	84.1	.....	24.5	23.5	.....
Müntz, Durand and Milliau (oils from Greece):[b]										
Minimum Maximum	.9160	.....	.....	30.0 35.0	83.3 97.2	84.3	.....	25.0	23.5	.....
Müntz, Durand and Milliau (oils from Turkey)[b]:										
Minimum Maximum	.9162	.....	.....	30.0 35.0	83.3 97.2	84.1	.....	24.5	23.0	.....
Müntz, Durand and Milliau (oils from the Levant):[b]										
Minimum Maximum	.9165	.....	.....	30.0 35.0	83.3 97.2	83.5	.....	24.5	23.0	.....

[a] 4 samples. Bulletin du Ministère de l'Agriculture, 1895, p. 139.
[b] Bulletin du Ministère de l'Agriculture, 1895, p. 139.

TABLE XL.—*Miscellaneous olive oils*—Continued.

Analysis.	Determinations.									
	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Saponification value.	Melting point of fatty acids.	Solidifying point of fatty acids.	Free fatty acids as oleic.
		Degrees.						° *C.*	° *C.*	*Perct.*
Müntz, Durand and Milliau (oils from Tunis):[a]										
Minimum	.9150	.....	.....	.....	.....	81.4	.....	24.0	22.5	.....
Maximum	.9182	.....	.....	.....	.....	85.2	.....	27.0	25.0	.....
Milliau, Bertainchand and Malet (oils from Tunis)[b]:										
Minimum	.9170	.....	.....	30.0	84.0	79.3	.....	24.8	20.2	0.60
Maximum	.9196	.....	.....	36.0	97.0	89.5	.....	38.0	31.9	7.6
Average	.9183	.....	.....	.....	.....	85.0	.....	32.0	.....	1.4
Müntz, Durand and Milliau (oils from France):[c]										
Minimum	.9154	.....	.....	30.0	83.3	83.5	.....	24.0	22.5	.....
Maximum	.9168	.....	.....	35.0	97.2	84.1	.....	25.0	24.0	.....
Tolman and Munson (oils from Montevideo):[d]	.....	68.9	1.4716	.....	.....	79.2	194.6	26.8	.....	1.40
Tolman and Munson (oils from San Antonio):[d]	.....	67.8	1.4710	.....	.....	83.4	190.7	23.4	.....	4.33

[a] 15 samples. Bulletin du Ministère de l'Agriculture, 1895, p. 139.
[b] 49 samples. Bulletin de l'Agriculture et Commerce de Tunis.
[c] 7 samples. Bulletin du Ministère de l'Agriculture, 1895, p. 139.
[d] These two South American oils were exhibited at the World's Fair, Chicago. From W. C. Blasdale, Berkeley, Cal.

COMMERCIAL OLIVE OILS.

One hundred and fifty-seven samples of commercial olive oils were examined, of which 72 were labeled French oils, 67 were Italian oils, 15 were California oils, and the remaining 3 were of miscellaneous origin. Sixty-one samples were furnished by the Treasury Department and came from the appraisers' stores at New York and Philadelphia; 96 samples were bought upon the markets at Boston, Buffalo, Chicago, New Haven, New Orleans, St. Louis, San Francisco, Oakland, and Washington. The following table summarizes the results obtained on these commercial oils:

TABLE XLI.—*Summary of commercial oils.*

Kind and source.	Total number of samples.	Samples containing oils other than olive.	Samples containing cotton-seed oil.
French oils:			
From appraiser's stores	33	3	0
Purchased in market	39	8	5
Italian oils:			
From appraiser's stores	28	2	0
Purchased in market	39	8	6
Total imported oils:			
From appraiser's stores	61	5	0
Purchased in market	78	16	11
California oils, purchased in market	15	2	2
Miscellaneous oils,[a] purchased in market	3	3	2

[a] One sample sold as "superior to any olive oil" was maize oil.

Descriptions of the commercial samples are given in Tables XLII, XLIV, XLVI, and XLVIII, and the results of the analyses are given

in Tables XLIII, XLV, XLVII, and XLIX. Table XLIII gives the results obtained on the commercial samples of California oils. These oils agree very closely with the California oils of known purity given in Table XXXV. The melting point of the fatty acids of No. 23114 is rather high, but the percentage of solid fatty acids is also high, and the iodin number is correspondingly low.

TABLE XLII.—*Description of commercial California oils not found adulterated.*

Serial No.	Source.	Capacity of receptacle.	Price.	Price of 10 ounces.	Label.
		Ounces.	*Dollars.*	*Dollars.*	
22432	C. C. Bryan, Washington, D. C.	20.3	1.00	0.49	California Olive Oil, Olivina. Julius Paul Smith, Livermore, Cal.
22616	F. J. Lea & Co., Oakland, Cal.	.....	.....	.....	
23069	Alameda Co., Boston, Mass.	15.5	.60	.38	California Olive Oil. Alameda Co., Boston, Mass. Absolutely Pure,
23099	Sunset Grocery Co., Oakland, Cal.	25.3	1.00	.39	Absolutely Pure. "San Pedro."
23101	Torrey & Gardiner, Oakland, Cal.	19.6	1.00	.51	Old Mission Olive Oil. Akerman & Tuffley, San Diego, Cal.
23109	A. Simon, San Francisco, Cal.	.....	.90	.....	Coburn's Olive Oil. Coburn, Tevis & Co., San Francisco, Cal.
23112	John Schloen, San Francisco, Cal.	19.2	1.00	.52	Gifford's Best California Olive Oil. Absolutely Pure. C. M. Gifford, Jamacha Valley, San Diego Co., Cal.
23114	L. Lebenbaum & Co., San Francisco, Cal.	20.3	1.85	.45	Santa Ana, California, Olive Oil. First Pressing.
23116	J. Caire Co., San Francisco, Cal.	22.0	1.00	.41	Pure Olive Oil. Quito Olive Farm, Santa Clara Co., Cal.
23117	.....do	20.9	1.00	.47	Pure Olive Oil. Pala Grove, Alum Rock, San Jose, Cal.
23118	.....do	19.6	1.00	.51	Pure Olive Oil. Olivina Farm, Auburn, Cal. Mrs. Emily Roberson.
23124	J. O. Riddel, Redlands, Cal.	.....	.....	.....	Riddel's Olive Oil. First Pressing. J. O. Riddel, Redlands, Cal.
23125	.....do	.....	.....	.....	Pure Olive Oil. F. M. Hunt, Redlands, Cal.

TABLE XLIII.—*Analyses of commercial California oils not found adulterated.*

Serial No.	Specific gravity at 15.5° C.	Butyro-refracto-meter reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Hübl number.	Iodin number of liquid fatty acids.		Saponification value.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
						Determined.	Calculated.				
		Degrees.							° *C.*	*Per ct.*	*Per ct.*
22432	0.9152	68.7	1.4715	41.0	84.5	.....	91.5	191.6	22.5	3.22	1.27
22616	.....	67.4	1.4707	.....	81.0	.....	.....	192.6	25.0	.....	3.49
23069	.9157	67.1	1.4705	43.0	79.0	.....	89.8	193.4	26.2	7.45	.....
23099	.9163	67.7	1.4708	43.5	81.6	88.4	85.9	190.5	21.9	4.01	.29
23101	.9177	67.9	1.4710	51.0	83.8	93.9	94.9	192.9	26.1	7.18	3.96
23109	.9163	67.9	1.4710	44.5	80.3	88.5	92.0	193.2	25.8	8.32	1.18
23112	.....	68.1	1.4711	46.3	79.9	.....	93.3	192.4	25.2	7.96	.....
23114	.9167	67.4	1.4707	49.5	79.9	94.9	97.0	194.9	33.4	13.20	.76
23116	.9171	68.9	1.4717	45.0	83.4	90.9	94.1	191.9	22.4	5.47	.69
23117	.9167	68.6	1.4714	43.8	83.7	89.4	92.1	192.2	20.7	3.62	.80
23118	.9164	68.0	1.4710	45.2	81.0	88.7	90.1	193.1	23.1	5.62	1.24
23124	.9171	68.2	1.4711	45.5	83.7	92.5	93.7	193.3	25.4	6.20	.47
23125	.....	67.9	1.4710	48.0	86.5	93.2	95.0	193.2	23.2	5.42	7.25
Average	.9165	68.0	1.4710	45.5	82.2	91.2	92.5	192.7	24.7	6.47	1.95
Maximum	.9177	68.9	1.4717	51.0	86.5	94.9	97.0	194.9	33.4	13.20	3.96
Minimum	.9152	67.1	1.4705	41.0	79.0	88.4	85.9	190.5	20.7	3.22	.29

The following letter was received in regard to the analytical results obtained on sample No. 23117:

OAKLAND, CAL., *April 28, 1903.*

In returning the accompanying statement of the chemical analysis of Pala Grove oil I would like to make one change. Just before receiving the paper from Washington I had a test made of this year's product by F. M. Curtis & Son, analytical chemists in San Francisco. They returned me the following:

Specific gravity at 15.5° C	0.9147
Free fatty acids (in terms of oleic) per cent	0.36
Iodin number (Hübl)	83.9
Cotton-seed oil	None.

You will note the difference in the percentage of free fatty acids, your analysis calling for 0.80 per cent. I was at a loss to account for the great difference until I recalled the age of the oil you had tested. The Justinian Caire Company have had no oil of ours since the 1901 crop, and when that was put in still had some of the 1900 crop on hand, so that what you bought from them was *at least* 2 years old.

Thanking you for your courtesy, I am, very respectfully,

CARRIE CUTLER MCLENEGAN.

PALA OLIVE GROVE, *San Jose, Cal.*

Tables XLIV and XLV give the description of the commercial French oils and the results obtained thereon. Tables XLVI and XLVII give the same data for commercial Italian oils. Like the Italian oils of known purity, the commercial French and Italian oils have a lower iodin value, a higher percentage of solid fatty acids, and the fatty acids have a higher melting point than the California oils.

TABLE XLIV.—*Description of commercial French olive oils not found adulterated.*

Serial No.	Source.	Capacity of receptacle.	Price.	Price of 10 ounces.	Label.
		Ounces.	*Dollars.*	*Dollars.*	
7049	Cobb, Bates, Yerxa & Co., Boston, Mass.	.....	.....	.....	Huile d'Olive Vierge, d'Aix, Dupont & Cie., Bordeaux, France.
20943	Appraiser's office, Port of Philadelphia.	9.8	.....	.....	Vidheau et Cie., Bordeaux.
20955	A. M. & J. Solari, New Orleans, La.	17.6	0.65	0.37	Huile d'Olive Vierge, J. L. Duret & Co., Bordeaux, France.
20956	.....do.....	19.6	.45	.23	Huile d'Olive Surfine, Adolphe Puget, Marseille.
20957	.....do.....	19.6	.40	.20	Huile d'Olive, Superfine Raffinée, James Plagniol, Marseille.
21003	J. A. Koehl, New Orleans, La.	18.6	.65	.35	V. S. O. Huile d'Olive, Extra Superfine, J. de Bric & Co., Bordeaux, France.
21063	J. G. Swarbuck, New Orleans, La.	9.12	.40	.44	Huile d'Olive Vierge, 9 oz. Qualité Supérieure, Larronde Frères, Bordeaux, France.
21071	S. W. Clark & Son, New Orleans, La.	20.2	.65	.32	Huile d'Olive, Extra Surfine, Talbot Frères, Bordeaux, France.
21072	.....do.....	20.2	.65	.32	Nicelle Olive Oil, Seville Packing Co., New York. Made in Nice, France.
21112	Appraiser's office, Port of Philadelphia.	20.9	.....	.....	Huile d'Olive, Superfine, A. de Luze & Fils, Bordeaux.
21397	.....do.....	20.0	.....	.....	Huile d'Olive, Superfine Extra. Packed expressly for I. J. Miller, 21st and Brandywine streets, Philadelphia, Pa.
21398	.....do.....	21.3	.....	.....	Huile d'Olive, Extra Surfine, Bordeaux. Bottled for Newton, Robertson & Co., Hartford, Conn.
21399	.....do.....	.....	.....	.....	Huile d'Olive, Garneau Frères, Bordeaux.
21870	Appraiser's office, Port of New York.	16.9	.....	.....	Huile d'Olive, Superfine Clarifiée, Barton & Guestier, Bordeaux.
21871	.....do.....	17.2	.....	.....	Huile d'Olive Vierge, Qualité extra supérieure, Beaumarchand Fils, Bordeaux.
21872	.....do.....	.....	.....	.....	
21873	.....do.....	.....	.....	.....	

TABLE XLIV.—*Description of commercial French olive oils not found adulterated*—C't'd.

Serial No.	Source.	Capacity of receptacle.	Price.	Price of 10 ounces.	Label.
		Ounces.	*Dollars.*	*Dollars.*	
21874	Appraiser's office, Port of New York.	.....	.....	.....	
21875	.....do.....	23.3	.....	.....	Huile d'Olive, Joseph Mayrargue, Nice, France.
21876	.....do.....	17.2	.....	.....	Huile d'Olive, Superfine Clarifiée, Roulan Frères, Bordeaux.
21877	.....do.....	16.9	.....	.....	Huile d'Olive, Qualité Supérieure, F. P. Garrettson & Co., New York City.
21878	.....do.....	.....	.....	.....	
21879	.....do.....	.....	.....	.....	
21880	.....do.....	.....	.....	.....	
21881	.....do.....	17.5	.....	.....	Huile d'Olive Vierge, Extra, James Plagniol, France.
21882	.....do.....	18.5	.....	.....	Sublime Olive Oil. Imported by W. P. Allen, Philadelphia, Pa.
21883	.....do.....	.....	.....	.....	
21884	.....do.....	.....	.....	.....	
21885	.....do.....	.....	.....	.....	
21886	.....do.....	.....	.....	.....	
21887	.....do.....	.....	.....	.....	
21888	.....do.....	27.4	.....	.....	Huile d'Olive, Boutelleau Fils. Made in France.
21889	.....do.....	.....	.....	.....	
21890	.....do.....	.....	.....	.....	
21891	.....do.....	.....	.....	.....	
21892	.....do.....	16.9	.....	.....	Huile d'Olive, Superfine, Jules Gaston & Cie., Bordeaux.
21893	.....do.....	.....	.....	.....	
21894	.....do.....	.....	.....	.....	
22908	Faxon, Williams & Faxon, Buffalo, N.Y.	17.9	0.70	0.39	Huile d'Olive Vierge bottled in Bordeaux, for Faxon, Williams & Faxon.
22913	John A. Seel, Rochester, N. Y.	22.0	.68	.31	Pure Olive Oil packed in Bordeaux for J. A. Seel.
22914	.....do.....	8.7	.40	.46	Huile d'Olive, Barton & Guestier, Bordeaux.
22918	E. C. Cochrane Co., Buffalo, N. Y.	30.4	.75	.25	Vierge Extra Huile d'Olive, E. C. Cochrane Co.
22919	.....do.....	17.5	.85	.49	Huile d'Olive, Brandenburg Frères, Bordeaux.
22920	Dingens Bros., Buffalo, N. Y.	.....	.....	.....	Huile d'Olive Vierge, J. E. Blanc, Marseille.
23066	S. S. Pierce, Boston, Mass.	32.1	1.25	.39	Huile d'Olive Vierge, Vve Chaffard, Jardin de la France.
23071	Cobb, Aldrich & Co., Boston, Mass.	8.7	.35	.40	Huile d'Olive de Nice, J. P. Fourché, Nice.
23088	R. N. Nesbit Co., New Haven, Conn.	16.9	.70	.41	Huile d'Olive, A. Fontenelle Fils & Cie., Grasse.
23092	E. E. Nichols, New Haven, Conn.	16.9	.80	.47	Huile d'Olive Laselle, Chapnelle & Cie., Aix.
23103	M. D. Myer, San Francisco, Cal.	15.2	.75	.49	Huile d'Olive, De Possel Fils, Marseille.
23105	Goldberg, Bowen & Co., San Francisco, Cal.	18.9	.65	.34	Huile d'Olive Vierge, bottled in Bordeaux.
23110	A. Liebmann, San Francisco, Cal.	23.0	.70	.30	Choicest Imported Olive Oil, bottled by A. Liebmann.
23111	Bebo, Newman & Ikenberg, San Francisco, Cal.	18.6	.75	.40	Huile d'Olive Vierge, Alphonse Billet, Bordeaux.
23128	L. Stumpf Grocery Co., St. Louis, Mo.	23.6	.95	.40	Huile d'Olive Vierge de Provence, L. A. Price, Bordeaux.
23129	Connor, Eagan Co., St. Louis, Mo.	22.0	.80	.36	Huile d'Olive, J. Mottet & Cie., Grasse.
23133	H. L. Epping, Chicago, Ill.	20.6	.75	.36	Club House Brand, Virgin Olive Oil, Grasse. Imported by Franklin MacVeagh & Co., Chicago.
23135	S. G. Anable, Chicago, Ill.	20.3	1.00	.49	Huile d'Olive Vierge, Alexis Godillot Jeune.
23136	Whiteman & Co., Chicago, Ill.	21.3	.90	.40	Huile d'Olive, Supérieure, Dumouron & Cie., Grasse.
23138	Hamelsfaler, Chicago, Ill.	16.2	.85	.52	Huile d'Olive Vierge, Alphonse Pinard, Bordeaux.
23139	C. Jevne & Co., Chicago, Ill.	19.2	1.00	.52	Huile d'Olive, St. Benedictus. Imported specially for Christian Jevne & Co., Chicago.
23140	.....do.....	21.3	.75	.35	Huile d'Olive, Société Hygiénique Alimentaire.
23141	.....do.....	24.3	.75	.30	Importé spécialement par C. Jevne & Co.
23083	Gilbert & Thompson, New Haven, Conn.	31.4	1.40	.44	Club Brand, Virgin Salad Oil. Imported by G. F. Heublein & Bro., Hartford, Conn.

TABLE XLV.—*Analyses of commercial samples of French olive oils not found adulterated.*

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification value.	Melting points of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								° C.	*Per ct.*	*Per ct.*
7049	0.9183	67.5	1.4707	.....	.....	85.0	.....	.....	.....	.....	.....	.....
20943	.9180	68.1	1.4711	43.2	96.0	80.3	91.5	.....	195.2	30.2	.....	1.32
20955	.9157	68.2	1.4711	42.0	93.2	79.8	90.6	.....	193.4	26.2	.....	1.32
20956	.9165	67.4	1.4707	45.2	100.3	83.0	97.4	.....	192.6	30.6	.....	1.56
20957	.9173	67.9	1.4709	48.8	108.4	81.4	.....	98.3	193.2	27.8	12.69	1.02
21003	.9164	68.0	1.4710	41.8	92.8	79.8	91.5	.....	192.7	25.2	.....	1.32
21063	.....	67.4	1.4707	40.7	90.4	80.5	95.5	92.2	192.3	25.2	8.21	2.62
21071	.9161	67.8	1.4709	43.6	96.9	79.0	.....	.....	194.1	26.0	.....	1.91
21072	.....	67.5	1.4707	42.0	93.3	80.9	89.5	88.1	192.3	25.2	3.74	.76
21112	.....	67.8	1.4709	47.2	104.9	81.2	90.0	.....	193.5	30.6	.....	1.56
21397	.9163	67.3	1.4706	42.0	93.2	81.3	93.2	95.1	192.8	25.0	10.14	1.52
21398	.9167	67.0	1.4704	43.8	97.3	80.8	94.1	98.5	193.1	29.4	13.56	1.20
21399	.9169	67.5	1.4707	43.8	97.3	81.4	93.9	97.7	193.0	25.8	12.20	2.16
21870	.9164	67.6	1.4707	45.2	100.3	80.7	91.2	.....	192.8	29.0	.....	2.29
21871	.9163	68.0	1.4710	43.8	97.3	79.5	91.6	94.7	194.4	.....	11.62	3.63
21872	.9165	67.3	1.4706	43.0	95.5	79.9	93.2	93.8	192.6	27.0	10.44	.92
21873	.9167	68.0	1.4710	46.5	103.3	81.8	99.4	97.8	193.5	27.0	11.94	.66
21874	.9166	67.6	1.4708	47.2	104.9	82.9	94.6	.....	195.0	28.2	.....	1.55
21875	.9163	67.8	1.4709	44.4	98.6	81.4	92.6	93.9	191.6	26.7	8.92	.96
21876	.9163	67.5	1.4707	44.4	98.6	79.7	94.9	96.0	192.8	.....	12.50	2.75
21877	.9166	68.1	1.4711	44.6	99.1	80.0	96.0	.....	194.8	29.4	.....	2.00
21878	.9166	67.8	1.4709	45.0	100.0	79.0	.....	97.4	195.3	28.0	14.46	2.39
21879	.....	68.0	1.4711	47.6	105.8	84.2	100.0	97.5	192.6	28.4	9.26	1.55
21880	.9172	68.5	1.4713	47.4	105.3	83.1	98.4	100.0	193.5	27.0	12.38	.45
21881	.9165	68.0	1.4710	41.4	92.0	80.1	.....	96.3	194.5	28.2	12.36	.71
21882	.9174	68.0	1.4710	47.4	105.3	80.8	92.7	99.7	194.0	30.4	14.45	.90
21883	.9167	68.2	1.4711	47.4	105.3	83.8	.....	99.7	192.1	25.2	11.56	.52
21884	.9170	68.1	1.4710	42.4	94.2	83.7	93.1	93.8	193.5	27.2	6.33	1.76
21885	.....	68.2	1.4711	44.4	98.6	80.2	95.7	95.7	193.6	28.0	11.93	.66
21886	.9165	67.8	1.4709	42.8	95.1	80.9	.....	94.1	194.2	27.2	9.58	.89
21887	.9153	67.6	1.4707	45.5	101.1	81.2	.....	92.6	192.1	28.8	7.89	1.34
21888	.9173	67.5	1.4707	42.4	94.2	80.1	.....	98.1	194.3	24.6	13.95	1.09
21889	.9163	67.7	1.4707	42.1	93.5	80.8	96.0	94.3	195.3	26.7	9.92	.47
21890	.....	68.0	1.4711	44.0	97.8	82.8	93.7	94.3	193.6	26.9	7.73	.89
21891	.....	67.8	1.4709	43.7	97.1	82.5	93.2	94.6	192.7	27.4	8.34	.84
21892	.9163	68.0	1.4710	40.7	90.4	79.8	91.3	.....	195.1	28.0	.....	2.14
21893	.9163	67.5	1.4707	41.4	92.0	81.5	.....	91.1	191.7	23.7	6.17	.48
21894	.....	67.5	1.4707	42.6	94.6	81.1	.....	.....	194.2	24.7	.....	3.44
22908	.....	68.7	1.4709	42.2	93.7	80.9	.....	91.2	193.5	24.2	6.81	3.18
22913	.....	67.2	1.4704	42.8	95.5	80.2	90.6	89.7	193.2	25.2	6.11	1.83
22914	.9153	67.3	1.4705	45.5	101.1	83.6	.....	.....	193.1	27.6	.....	2.58
22918	.9152	67.8	1.4709	42.4	94.2	80.9	.....	.....	191.2	26.3	.....	2.28
22919	.9157	68.0	1.4711	42.5	94.4	81.9	93.1	94.6	193.6	27.2	9.06	1.98
22920	.9167	66.4	1.4699	51.5	114.4	83.6	92.1	.....	191.7	27.2	.....	1.82
23066	.9161	67.2	1.4705	48.8	108.4	82.5	.....	94.8	192.6	25.0	8.56	1.06
23071	.9170	67.1	1.4705	47.2	104.9	80.6	.....	91.1	191.7	27.5	7.11	2.93
23088	.9167	67.6	1.4708	44.0	97.8	80.6	.....	89.5	192.8	25.0	5.53	1.73
23092	.9177	67.4	1.4706	51.4	114.2	80.5	.....	96.2	194.2	30.0	15.95	1.07
23103	.9196	67.4	1.4706	47.6	105.8	82.5	91.1	97.9	193.0	29.6	11.37	2.06
23105	.9168	67.8	1.4708	48.2	107.1	80.8	93.4	94.2	191.3	28.6	9.87	1.38
23110	.9168	67.7	1.4709	49.4	109.7	84.2	.....	101.8	193.0	30.8	12.81	1.66
23111	.9173	67.8	1.4708	50.0	111.1	80.4	94.7	97.3	193.1	29.4	12.90	.81
23128	.9166	67.6	1.4707	48.2	107.1	81.4	92.8	93.5	192.2	27.2	8.50	1.62
23129	.9160	67.8	1.4709	46.0	102.2	82.2	.....	92.8	192.1	29.0	6.99	.95
23133	.9177	67.5	1.4707	44.0	97.8	80.5	.....	89.1	190.5	23.8	5.25	.90
23135	.9170	67.7	1.4708	46.0	102.4	81.0	.....	95.7	191.5	28.0	10.90	.99
23136	.9158	67.2	1.4705	45.4	100.8	79.4	.....	91.3	192.3	27.8	8.59	2.27
23138	.9150	67.6	1.4707	45.4	100.8	82.2	.....	.....	193.3	26.3	.....	1.69
23139	.9165	67.6	1.4707	49.5	110.0	81.4	97.9	97.1	192.0	29.6	11.70	1.71
23140	.9164	67.6	1.4707	46.5	103.3	80.5	94.7	93.0	191.3	28.1	8.98	2.22
23141	.9172	67.2	1.4705	48.0	106.6	80.1	92.3	93.7	191.3	27.7	10.00	3.31
Av.	.9166	67.7	1.4708	45.1	100.1	81.3	93.7	94.9	193.0	27.3	9.98	1.59
Max.	.9196	68.7	1.4713	51.5	114.4	85.0	100.0	101.8	195.3	30.8	15.95	3.63
Min.	.9150	66.4	1.4699	40.7	90.4	79.0	89.5	88.1	190.5	23.7	3.74	.45

TABLE XLVI.—*Description of Italian olive oils not found adulterated.*

Serial No.	Source.	Capacity of receptacle.	Price.	Price of 10 ounces.	Label.
		Ounces.	*Dollars.*	*Dollars.*	
21907	Appraiser's office, Port of New York.				Bari.
21911	do				Bari.
22910	John A. Seel, Rochester, N. Y.	131.0	2.50	0.19	Olio d'Oliva Finissimo, Garantito Genuino, A. Nicolini, Bari.
21895	Appraiser's office, Port of New York.				Sorrento.
21908	do				Naples.
21915	do				Naples.
23082	Santo Capasso, New Haven, Conn.	71.0	1.00	.14	Olio d'Oliva Finissimo, Faicchio & S. Lorenzello, Prov. di Benevento.
20958	A. M. & J. Solari, New Orleans, La.	16.2	.55	.34	Olio d'Oliva di Lucca, F. Bertolli.
21111	Appraiser's office, Port of Philadelphia.				Olio d'Oliva Suprafino, F. Bertolli, Lucca.
21199	do	8.4			Lucca Finest Cream Salad Oil, Warranted Pure Olive Oil. Smith, Kline & French Co., Philadelphia.
21896	Appraiser's office, Port of New York.				Lucca.
21897	do				Lucca.
21898	do				Lucca.
21899	do				Lucca.
21902	do				Lucca.
21909	do				Lucca.
23068	S. S. Pierce, Boston, Mass.	10.1	.35	.34	Pure and Best Cream Olive Oil.
23093	Booth Meat Co., New Haven, Conn.	18.6	.75	.40	Cream Olive Oil, Made in Leghorn for W. A. Castle, Springfield, Mass.
23095	Bronson & Platt Co., New Haven, Conn.	8.7	.35	.40	Huile d'Olive Excelsior, Toscana Excelsior, Lucca.
23097	H. Olson, Oakland, Cal.	23.6	.65	.27	Pure Lucca Oil, Crosse & Blackwell, London.
23100	Agard & Russell, Oakland, Cal.	24.7	.85	.34	Extra Sublime Cream Lucca Olive Oil.
23106	John Bulotti, San Francisco, Cal.	25.4	.65	.25	Fine Lucca Oil, Imported by John Bulotti, San Francisco, Cal
23107	H. Weeden, San Francisco, Cal.	13.5	.50	.37	The Best Lucca Olive Oil, G. Fontana & Co., San Francisco, Cal.
23113	Goldberg, Bowen & Co., San Francisco, Cal.	19.9	.60	.30	Sublime Lucca Oil, Goldberg, Bowen & Co., San Francisco, Cal.
23122	Mrs. C. Goessel, San Francisco, Cal.	21.3	.65	.30	Genuine Italian Olive Oil, M. Ricci & Co., Lucca.
23123	H. Glander, San Francisco, Cal.	23.6	.60	.25	Pure Lucca Olive Oil, Robert Baldocchi & Co., San Francisco, Cal.
21900	Appraiser's office, Port of New York.				Leghorn.
21901	do				Leghorn.
21905	do				Leghorn.
21910	do				Leghorn.
21912	do				Leghorn.
21917	do				Leghorn.
21918	do				Leghorn.
22907	Faxon, Williams & Faxon, Buffalo, N. Y.	19.2	.70	.36	Finest Sublime Lucca Olive Oil, S. Rae & Co., Leghorn.
22911	John A. Seel, Rochester, N. Y.	68.1	1.50	.22	Sublime Italian Lucca Olive Oil, G. Bartoni, Leghorn.
22912	John A. Seel, Rochester, N. Y.	23.6	1.25	.52	The Routh Extra Sublime Lucca Olive Oil, H. L. Routh & Sons.
22915	E. M. Buehl, Buffalo, N. Y.	16.9			Extra Cream Lucca Olive Oil, D. G. Rossetti & Co., Leghorn.
22921	Dingens Bros., Buffalo, N. Y.	10.1	.65	.64	Pure Genuine Olive Oil, Augustus Achiardi, Leghorn.
22922	do				A. Nicolini.
23094	Booth Meat Co., New Haven, Conn.	12.5	.35	.28	Huile d'Olive Lucca, Nicoli Pitito, Leghorn.
23104	L. M. Walter, San Francisco, Cal.	27.1	1.00	.36	Olio Soprafino, Fratelli Alfonso, Leghorn, Lucca.
23132	Schliewohl & Peterson, Chicago, Ill.	19.0	.70	.36	Finest Sublime Lucca Oil, S. Rae & Co., Leghorn.
23134	Geo. P. Popf, Chicago, Ill.	18.9	.75	.39	Extra Superfine Italian Salad Oil, Warranted Pure Olive Oil, Antonini & Co., Leghorn.
23074	Conway Co., Boston, Mass.	18.6	.75	.40	Olio d'Oliva di Lucca, Ditta Ferd. Nencioni, Pisa. B. Ferrari & Co., Boston, sole importers.
23073	The Ginter Grocery Co., Boston, Mass.	18.2	.60	.33	Pure Tuscan Olive Oil, William Lloyd & Co., Leghorn.
21903	Appraiser's office, Port of New York.				Genoa.

FIG. 1.—LABEL ON BOTTLE OF MAIZE OIL.
(SEE PAGE 5.)

FIG. 2.—LABEL ON OLIVE OIL MIXED WITH COTTON-SEED OIL.
(SEE PAGES 4 AND 60.)

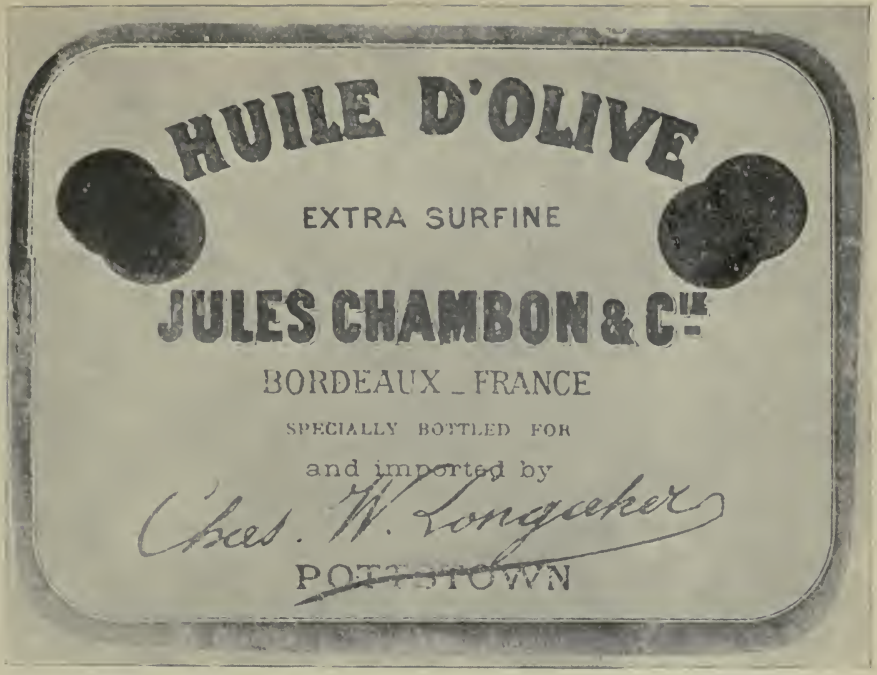

FIG. 1.—LABEL ON OLIVE OIL MIXED WITH PEANUT OIL. (SEE PAGES 5 AND 60.)

FIG. 2.—LABEL ON BOTTLE OF COTTON-SEED OIL. (SEE PAGES 4 AND 60.)

TABLE XLVI.—*Description of Italian olive oils not found adulterated*—Continued.

Serial No.	Source.	Capacity of receptacle.	Price.	Price of 10 ounces.	Label.
		Ounces.	*Dollars.*	*Dollars.*	
21904...	Appraiser's office, Port of New York.	.....	.....	.....	Genoa.
21913...	.....do	.....	.....	.....	Genoa.
21916...	.....do	.....	.....	.....	Genoa.
21919...	.....do	.....	.....	.....	Genoa.
23119...	Smith Cash Store, San Francisco, Cal.	17.1	.60	.35	Olio Vero d'Oliva Pio Moro fu Cornigliano, Liguria.
22909...	A. Z. Giannelli, Buffalo, N. Y.	30.4	1.00	.32	Pure Olive Oil, A. Z. Giannelli, Casciana d'Monsagrati.
23067...	S. S. Pierce, Boston, Mass.	21.9	.65	.30	Pure Olive Oil, Italy, S. S. Pierce & Co., Boston, Mass.
23084...	E. E. Hall & Sons, New Haven, Conn.	30.4	.90	.29	Italian Olive Oil, Edw. E. Hall & Son, New Haven, Conn.
23187...	V. Kaufman, Chicago, Ill.	.....	.75	.....	Collinfiore Royal Table Olive Oil, Italy.
21029...	Popovich & Abramovich, New Orleans, La.	128.0	1.90	.15	Giov. di Cola, Termini, Sicily.
21914...	Appraiser's office, Port of New York.	.....	.....	.....	Messina.

TABLE XLVII.—*Analyses of commercial samples of Italian olive oils not found adulterated.*

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification number.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								°C.	*Per ct.*	*Per ct.*
21907....	0.9171	67.7	1.4708	42.1	93.6	81.2	93.7	97.5	193.3	.....	12.28	2.22
21911....	.9152	67.2	1.4704	41.9	93.1	81.1	.....	98.1	193.5	.....	12.95	4.56
22910....	.9165	67.0	1.4704	47.0	104.4	82.4	91.9	.....	194.2	28.4	.....	4.61
21895....	.9167	67.1	1.4703	42.0	93.3	77.9	90.6	94.8	193.7	28.4	13.42	2.72
21908....	.....	67.8	1.4709	42.2	93.7	80.9	91.2	94.0	193.5	25.2	9.46	3.18
21915....	.9134	66.2	1.4698	47.6	105.8	82.4	.....	94.1	194.1	26.7	8.04	15.25
23082....	.9161	67.4	1.4706	47.7	106.0	82.2	.....	.....	193.4	29.6	.....	4.40
20958....	.9159	67.5	1.4707	40.0	88.9	79.7	.....	89.6	193.5	24.0	6.57	1.69
21111....	.9163	67.4	1.4707	42.0	93.4	80.9	92.5	.....	192.6	27.2	.....	1.06
21199....	.....	67.5	1.4707	41.4	92.0	81.2	90.0	.....	192.2	25.9	.....	1.53
21896....	.....	67.6	1.4708	44.0	97.7	82.4	.....	.....	196.6	28.2	.....	1.18
21897....	.9159	67.2	1.4705	40.5	90.0	79.2	90.8	.....	194.5	27.7	.....	.78
21898....	.9167	67.8	1.4709	46.0	102.0	81.4	92.7	94.8	192.6	28.3	9.66	1.83
21899....	.9163	67.3	1.4705	42.6	94.6	81.2	91.4	93.9	193.0	29.2	9.16	2.16
21902....	.9154	67.9	1.4710	42.7	94.8	82.8	98.6	96.3	193.1	27.2	9.58	3.32
21909....	.....	67.2	1.4704	41.4	92.0	81.4	.....	92.0	192.3	.....	7.16	1.75
23068....	.9166	67.9	1.4705	45.0	100.0	80.1	93.8	91.9	192.1	28.9	8.50	2.63
23093....	.9161	67.2	1.4705	48.8	108.4	79.9	.....	88.8	192.7	22.8	5.58	1.07
23095....	.9166	68.3	1.4712	48.5	107.7	82.1	94.2	.....	192.4	28.5	.....	.93
23097....	.9153	67.1	1.4705	43.5	96.6	79.6	90.0	90.6	191.5	26.9	7.69	1.51
23100....	.9158	67.1	1.4705	48.2	107.1	82.0	91.7	.....	192.6	23.8	.....	4.28
23106....	.9156	67.2	1.4705	45.4	100.9	80.9	.....	90.0	191.8	25.0	6.80	1.29
23107....	.9152	67.1	1.4704	46.8	104.0	80.5	.....	90.1	191.1	22.6	6.25	3.17
23113....	.9155	67.0	1.4704	45.0	100.0	79.4	90.4	91.2	191.3	27.8	8.50	2.33
23122....	.9167	67.3	1.4706	47.7	106.0	81.4	.....	93.3	191.1	26.3	8.29	3.09
23123....	.9165	67.6	1.4708	44.0	97.6	80.1	91.8	90.7	191.2	24.6	7.22	1.29
21900....	.....	67.5	1.4706	41.2	91.5	80.9	91.3	92.1	192.5	25.8	7.69	1.74
21901....	.....	67.2	1.4704	41.4	92.0	80.6	.....	91.0	193.8	26.8	6.97	1.76
21905....	.....	67.8	1.4709	41.2	91.5	80.7	.....	.....	192.2	27.9	.....	2.12
21910....	.9166	67.3	1.4705	39.8	88.4	80.9	91.1	91.5	191.6	25.6	7.14	1.61
21912....	.9173	67.5	1.4706	44.0	97.8	81.6	94.7	94.9	192.2	28.0	9.54	2.90
21917....	.....	67.4	1.4705	42.6	94.6	80.9	.....	91.6	193.8	28.3	7.23	1.93
21918....	.9152	67.8	1.4709	42.4	94.2	81.9	.....	.....	.....	.....	.....	2.28
22907....	.9157	66.7	1.4701	45.0	100.0	80.1	91.0	88.0	191.9	23.8	5.44	1.06
22911....	.9155	67.5	1.4707	43.6	96.9	82.5	.....	.....	192.8	24.3	.....	1.31
22912....	.9163	67.4	1.4706	43.0	95.5	80.1	.....	.....	191.2	25.1	.....	1.26
22915....	.9157	66.9	1.4702	45.0	100.0	80.1	92.4	91.1	192.2	28.6	7.60	1.74
22921....	.....	67.1	1.4704	43.0	95.5	80.2	90.1	90.4	190.1	26.1	6.80	2.15
22922....	.9170	67.6	1.4708	46.0	102.2	79.7	93.3	.....	194.0	28.0	.....	3.89
23094....	.9169	67.6	1.4708	45.9	102.0	79.2	90.2	.....	191.6	26.2	.....	1.65
23104....	.9166	67.6	1.4708	46.0	102.2	80.6	93.0	91.6	190.5	25.1	7.53	1.16
23132....	.9163	67.3	1.4706	44.0	97.6	79.3	.....	89.8	190.2	26.3	7.28	.90
23134....	.9159	67.5	1.4707	44.5	98.8	79.2	93.0	90.9	190.9	27.1	8.28	.98

TABLE XLVII.—*Analyses of commercial samples of Italian olive oils not found adulterated*—Continued.

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer reading at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of liquid fatty acids.		Saponification number.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.
							Determined.	Calculated.				
		Degrees.								°C.	*Per ct.*	*Per ct.*
23074	.9165	66.8	1.4701	45.9	102.0	81.2	.....	88.4	191.6	24.4	3.70	2.46
23073	.9175	67.1	1.4705	41.4	92.0	78.5	.....	90.0	191.9	21.0	8.52	1.22
21903	.9150	67.3	1.4705	41.4	92.0	80.6	91.9	95.1	192.5	29.4	10.74	3.87
21904	.9162	67.8	1.4709	44.2	98.2	81.6	.....	94.8	192.4	29.4	9.47	1.59
21913	.9163	67.2	1.4704	42.8	95.1	80.2	90.6	95.2	193.2	25.2	11.26	1.83
21916	.9179	67.6	1.4707	44.7	99.3	81.5	92.7	98.5	194.6	30.4	12.68	2.09
21919	.9157	68.0	1.4711	42.5	94.4	84.5	99.7	100.2	193.6	27.2	11.21	1.98
23119	.9156	66.9	1.4703	47.5	105.5	82.6	93.3	.....	193.5	28.0	.....	5.30
22909	.9154	66.8	1.4701	44.0	97.8	82.7	.....	90.8	192.7	26.0	4.57	2.27
23067	.9159	66.9	1.4702	44.4	98.6	80.8	.....	92.8	192.1	25.6	8.50	2.63
23084	.9165	67.4	1.4706	48.4	107.5	83.3	.....	94.4	192.6	25.0	7.38	.72
23137	.9154	68.0	1.4710	44.2	98.2	82.5	.....	90.5	193.7	24.2	4.40	1.60
21029	.....	66.3	1.4699	40.8	90.7	77.5	91.9	91.9	190.9	26.2	11.22	3.61
21914	.9153	67.3	1.4705	45.5	101.1	83.6	94.5	.....	193.1	30.4	.....	2.58
Av.	.9161	67.3	1.4706	44.0	97.8	80.9	92.4	92.61	192.6	26.6	8.35	2.42
Max.	.9179	68.3	1.4712	48.8	108.4	84.5	99.7	100.2	196.6	30.4	13.42	15.25
Min.	.9134	66.2	1.4698	39.8	88.4	77.5	90.0	88.0	190.1	21.0	3.70	.72

Tables XLVIII and XLIX give the data obtained upon the samples of commercial oils found to be adulterated. The samples containing peanut oil all bore French labels and those containing sesame oil Italian labels. Two California oils contained cotton-seed oil. In all of the above cases the oils were represented to be pure olive oil and in most cases were guaranteed pure and of special grade. One of the most striking facts brought out by this examination of imported oils received from the customs officers, and therefore, known to be imported, was that none of them was adulterated with cotton-seed oil.

TABLE XLVIII.—*Description of adulterated olive oils.*

Serial No.	Source.	Capacity of receptacle.	Price.	Price of 10 ounces.	Label.
		Ounces.	*Dollars.*	*Dollars.*	
21027	A. L. Bühler, New Orleans, La.	7.4	0.10	0.13	Huile d'Olive Vierge. E. Loubon, Nice, France.
21031	Popovich and Abramovich, New Orleans, La.	59.5	.90	.17	Olio d'Oliva. Egisto Dini, Lucca, Italy.
21110	Appraiser's office, port of Philadelphia.	.....	.....	.....	Sublime Olive Oil. Addisoni Fils, Masina, Italy.
21113	.....do.....	.....	.....	.....	Huile d'Olive, Extra Surfine. Jules Chambon & Cie., Bordeaux, France. Imported by Chas. W. Longaker, Pottstown.
21395	.....do.....	.....	.....	.....	Huile d'Olive. P. M. Loubric, Bordeaux, France. Packed for I. K. Bean.
21396	.....do.....	.....	.....	.....	Huile d'Olive. P. M. Loubric, Bordeaux, France. Imported for J. M. Oliver & Sons.
21906	.....do.....	.....	.....	.....	Lucca, Italy.
22924	Dingens Bros., Buffalo, N. Y.	67.0	1.40	.20	Olio Sopraffino. Umberto Albertini, Livorno, Italy.
22925	.....do.....	120.1	2.25	.19	Olio Puro d'Oliva. Restivo & Co., Lucca, (Tuscania), Italy.
23070	Rice Bros., West Newton, Mass.	.....	.35	.....	Huile d'Olive, Vierge. Silas Peirce & Co., Bordeaux, France.

TABLE XLVIII.—*Description of adulterated olive oils*—Continued.

Serial No.	Source.	Capacity of receptacle.	Price.	Price of 10 ounces.	Label.
		Ounces.	*Dollars.*	*Dollars.*	
23072...	Cobb, Bates, Yerxa & Co., Boston, Mass.[a]	16	0.55	0.34	Huile d'Olive Vierge, d'Aix. Dupont & Cie., Bordeaux, France.
23085...	E. E. Hall & Son, New Haven, Conn.	11.5	.59	.51	Huile d'Olive, Extra Vierge. Naegely & Pasero, Marseille, France.
23086...	.....do.....	11.5	.45	.39	Huile d'Olive, Vierge, d'Aix. Alex. Eyquem, Bordeaux, France.
23087...	S. Franciscoui, New Haven, Conn.	34.1	.50	.14	Olio d'Oliva. Luigi di Cos Matteucci, Lucca, Italy.
23090...	G. Savarese, New Haven, Conn.	29.7	.50	.15	Olio d'Oliva, Sopraffino. F. Berio & Co., Lucca, Tuscana, Italy.
23096...	D. M. Welch & Son, New Haven, Conn.	8.7	.30	.34	Huile d'Olive, Extra Surfine. Tisserand & Fils, Bordeaux, France.
23108...	F. W. Ruchers & Co., San Francisco, Cal.	18.6	.50	.26	Olio d'Oliva, Sopraffino. Gaetano Giurlani, Lucca, Italy.
23120...	H. C. Kätterhorn, San Francisco, Cal.	25.3	.65	.25	Olio d'Oliva Vergine. De Martini E Cia., Riviera di Genova, Italy.
23121...	S. Scatena, San Francisco, Cal.	24.3	.50	.20	Olio Vergine Purissimo. Garantito di Lucca. S. Scatena & Co.
23131...	Luyties Bros., St. Louis, Mo.	.....	.25	.....	Huile d'Olive, Clarifée. Martinot Frères, Bordeaux, France.
23089...	D. Dove, New Haven, Conn.[b]	4.1	.10	.25	Huile Salad. Giacomo Luigi, Nove Orleons, Americano.
21030...	Popovich & Abramovich, New Orleans, La.	.....	1.00	.....	T. A. Fucich & Son, Lussinpiccolo, Austria.
22916...	Boston Store, Buffalo, N. Y.	11.1	.12	.18	Huile d'Olive. Frères & Du Peaux, Bordeaux, France.
22917...	.....do.....	.....	.43	.....	Superior in Quality, Purity, and Flavor to any Olive Oil in the market. Dove Pure Oil Co.
23098...	Howland & Co., Oakland, Cal.[c]	20.2	.60	.30	Olive Oil. El Montecito Man'f'g. Co., El Montecito, Cal.
23102...	W. P. Wheeler, Oakland, Cal.[c]	24.7	.65	.26	"Ramona" Pure Olive Oil. W. P. Wheeler, Oakland, Cal.

[a] On being notified that this oil contained peanut oil, Cobb, Bates & Yerxa replied, "We wish to say to you that we buy the Dupont oil to be not only pure olive oil but the best to be had." A second sample of a different shipment, secured by our representative from Cobb, Bates & Yerxa without their knowledge, was found to be pure. For analysis of pure sample, No. 7049, see page 55.

[b] A letter addressed to Giacomo Luigi, New Orleans, La., was returned unopened.

[c] See correspondence given below.

The following letters were received in regard to the two brands of California oil found to be adulterated. The second letter needs no comment, but the first brings out a very important fact, namely, the use or misuse of labels of well-known brands to cover gross adulterations.

MONTECITO, CAL., *May 7, 1903.*

Yours of 14th ultimo, with analysis of "El Montecito Manufacturing Company's Olive Oil," at hand.

In reply, I beg to state that the above company was organized in 1893 to make a *really pure* olive oil, and it never put out or sold a drop of any but pure olive oil.

The making of oil was discontinued in 1896 and the last of the stock on hand was sold in August, 1899, to Haas Brothers, of San Francisco, some 1,400 bottles. The machinery was sold last year, and the fine stone building costing nearly $7,000 is for sale. *Pure* olive oil could not be sold in competition with adulterated spurious oils, and as the parties interested in this company would not resort to such methods, the company simply went out of business. The company never sold any oil to Howland & Co., of Oakland.

Respectfully, yours,

EL MONTECITO M'F'G CO.,
EDWIN H. SAWYER *President.*

OAKLAND, CAL., *May 6, 1903.*

Your favor under date of April 14, 1903, at hand and contents noted. Beg to say in reply that I am much surprised to learn result of your analysis of my "Ramona" brand of olive oil, as when I adopted this brand for my retail trade I had the oil thoroughly analyzed, with result showing freedom from any adulterants. I presumed that the same brand of oil from the same producers and importers would run same in quality and purity, but it seems, as you remark in your favor referred to before, that "manufacturers vary in the goods they turn out." It must be so in this case, and I shall certainly change the oil and obtain a *pure* oil.

Permit me to say that I am not a wholesaler, simply bottling oil for my *retail* business. It seems, on my part, to be simply a case of too much trust imposed in manufacturers' agents.

I would remark that parties to whom I have submitted a sample of oil, now bottled under brand mentioned, for analysis, report adulteration of about 5 per cent. However, that would suffice to necessitate its being discarded as a pure article.

I beg to remain, yours, truly,

W. P. WHEELER.

The Department of State, upon the request of the Secretary of Agriculture, instructed the United States consul at Bordeaux to investigate the existence of the firms named on the labels reproduced on Plates I and II as manufacturers of olive oil at that port. The following excerpts are made from the report rendered by the consul:

1. No such firms as Tisserand & Fils, or Frères & Du Peaux, or Jules Chambon & Cie are known in this consulate or appear on the books thereof during the year 1903.

2. No such firms are to be found in the last directory of the city of Bordeaux.

Whether there are such firms in Bordeaux can be conclusively determined only by an examination of the registry books, for which a fee of 35 centimes (7 cents) per volume is charged for each volume included in the search. * * *

It is well-nigh impossible that there should be such a firm as "Frères & Du Peaux." It might be "Dupeaux Frères" or "Dupeaux & Frères." * * *

From all I can gather I think there is somewhere in Bordeaux a firm which sometimes calls itself "Jules Chambon & Cie," but where it is, who compose it, or what is its business the most searching inquiry has failed to reveal. Of the other two firms named not even a trace or suspicion can be found.

I am, sir, very respectfully, your obedient servant,

ALBION W. TOURGEE,

Consul of the United States of America at Bordeaux, France.

JULY 30, 1903.

TABLE XLIX.—*Analyses of adulterated olive oils.*

Serial No.	Specific gravity at 15.5° C.	Butyro-refractometer readings at 15.5° C.	Index of refraction at 15.5° C.	Maumené number.	Specific temperature reaction.	Hübl number.	Iodin number of free fatty acids.		Saponification value.	Melting point of fatty acids.	Solid fatty acids.	Free fatty acids as oleic.	Halphen test.	Renard test.	Baudouin test.	Adulterant.
							Determined.	Calculated.								
		Degrees.								°C.	*Per ct.*	*Per ct.*				
21027	.....	72.8	1.4740	77.8	172.9	107.2	142.0	.....	195.8	37.2	.....	0.30	Positive	.....	.....	Cotton-seed oil
21030	0.9207	70.7	1.4727	67.8	150.6	93.3	.....	.....	194.8	35.7	.....	1.78	.....do	.....	.....	Do.
21031	.9228	72.3	1.4737	70.2	156.0	94.9	.....	.....	197.0	37.2	.....	2.25	.....do	.....	.....	Do.
21110	.9166	68.0	1.4710	42.4	94.2	85.2	97.5	96.7	191.4	26.0	7.40	1.50	Negative	Negative	Positive	Sesame oil.
21113	.9150	67.6	1.4708	45.2	100.3	81.1	98.0	94.9	192.2	26.7	10.15	1.98	.....do	Positive	Negative	Peanut oil.
21395	.9166	67.4	1.4707	43.4	96.4	80.7	93.2	.....	191.7	25.2	10.83	1.63	.....do	.....do	.....do	Do.
21396	.9169	67.3	1.4706	41.8	92.9	81.0	92.1	94.7	192.4	27.0	9.96	2.04	.....do	.....do	.....do	Do.
21906	.9173	67.9	1.4710	45.7	101.5	81.1	92.1	95.7	193.2	26.0	10.78	1.88	.....do	.....	Positive	Sesame oil.
22924	.9213	71.0	1.4729	.....	.....	102.4	136.7	.....	196.5	37.8	.....	1.40	Positive	Negative	Negative	Cotton-seed oil.
22916	.9225	72.9	1.4740	.....	.....	105.8	.....	136.3	194.4	37.9	17.87	.07	.....do	.....	.....	Do.
22917	.9218	75.5	1.4756	.....	.....	107.7	117.3	121.4	191.4	24.2	6.87	.20	Negative	Negative	Negative	Maize oil.
22925	.9215	73.3	1.4742	.....	.....	107.4	133.0	.....	195.5	37.6	.....	1.16	Positive	.....do	Negative	Cotton-seed oil.
23070	.9170	67.9	1.4709	49.2	109.3	82.7	.....	96.3	191.4	24.5	9.73	1.60	Positive (weak)	Positive	Slight, 1 to 2 per cent.	Peanut oil.
23072	.9159	67.2	1.4705	46.2	102.6	81.4	.....	94.8	191.9	29.0	9.68	1.43	Negative	.....do	Negative	Do.
23085	.9200	69.9	1.4722	67.5	150.0	90.1	.....	.....	195.9	31.0	.....	.40	Positive	.....	.....	Cotton-seed oil.
23086	.9159	68.0	1.4710	52.5	116.6	82.5	.....	98.2	190.8	27.0	11.47	1.49	Negative	Positive	Negative	Peanut oil.
23087	.9167	68.1	1.4710	45.2	100.4	82.9	93.0	100.0	193.8	28.0	12.60	2.17	.....do	Negative	Positive	Sesame oil.
23089	.9228	73.0	1.4741	.....	.....	108.3	139.9	141.5	194.3	38.2	19.04	.05	Positive	.....	.....	Cotton-seed oil.
23090	.9162	67.9	1.4709	48.0	106.6	82.3	95.4	97.6	192.7	25.4	11.27	2.22	Negative	.....	Positive	Sesame oil.
23096	.9181	68.8	1.4715	55.2	122.6	84.2	92.2	.....	192.0	27.9	.....	1.67	Positive	.....	.....	Cotton-seed oil.
23108	.9198	70.0	1.4723	69.5	154.4	93.8	104.5	113.1	192.8	32.1	12.60	1.08	.....do	.....	.....	Do.
23120	.9162	67.3	1.4706	47.0	104.4	80.6	.....	.....	190.7	27.8	.....	3.20	Positive, slight, 2 per cent.	.....	.....	Do.
23121	.9196	70.5	1.4726	69.0	153.4	97.4	.....	117.7	193.4	34.0	12.78	2.34	Positive	.....	.....	Do.
23131	.9227	72.7	1.4740	.....	.....	108.8	139.6	.....	196.5	38.0	.....	.16	.....do	.....	.....	Do.
23098	.9229	73.0	1.4741	.....	.....	109.9	137.4	.....	194.3	38.0	.....	.09	.....do	.....	.....	Do.
23102	.9195	70.1	1.4724	67.0	148.9	92.4	106.5	113.2	195.2	34.6	13.90	1.20	.....do	.....	.....	Do.

SUMMARY.

(1) The olive oil consumed in this country is largely imported from France and Italy. The amount produced in California is relatively small, although reports warrant the statement that California is capable of supplying the entire home demand.

(2) The cost of production of California oil is so much higher than that of the French and Italian oils that it competes with difficulty with the imported oils in the American market, even after the latter have paid duty amounting to 50 cents per gallon.

(3) The retail prices of the best grade of oil from the three sources are much the same, but the average prices of the imported oils are much less than that of the California oil, owing to the large amount of lower grade foreign oils that is marketed in this country.

(4) In the examination of olive oils for adulteration, a complete analysis is usually necessary to reveal the real nature of the oil. In cases of gross adulteration the qualitative tests, specific gravity, and index of refraction will often show the nature of the adulterant and the extent to which it is employed.

(5) The adulteration of foreign oils imported into this country is practiced to a much less extent than is popularly supposed. Only 5 of the 61 samples obtained from the customs officers were found to contain other than olive oil, and none of these contained cotton-seed oil.[a] On the other hand, oils bought upon the market, bearing labels indicating a foreign origin, were found to be quite extensively adulterated with cotton-seed oil. It seems, therefore, probable that these adulterated oils bearing foreign labels are labeled and modified after leaving the port of entry, neither the domestic nor the foreign producer being responsible for them. This practice is equally injurious to the interests of the California, French, or Italian manufacturer of pure olive oil and the consumer.

(6) The results of analyses of oils of known purity show that there is a wide range in the various values ordinarily considered of importance in indicating the purity of an oil. This is especially true of the iodin number, the melting point of fatty acids, and the percentage of solid fatty acids. The California olive oils generally have a higher iodin number, a lower melting point of fatty acids, and a lower percentage of solid fatty acids than the French and Italian oils.

(7) All samples containing other than olive oil were sold as pure olive oil, although in one case a careful observation of the label revealed the fact that the oil was an olive oil substitute.

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[a] Nine samples out of 250 recently received from the custom-house have contained cotton-seed oil.

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