[CONTRIBUTION FROM THE OIL, FAT AND WAX LABORATORY, BUREAU OF CHEMISTRY, UNITED STATES DEPARTMENT OF AGRICULTURE]

THE CHEMICAL COMPOSITION OF SESAME OIL

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The sesame plant is widely cultivated throughout the warmer parts of Asia and Africa, particularly in India, Java, Siam, China, Egypt and the Levant. It is grown in smaller quantities in Brazil, Venezuela and Mexico. Sesame oil is an important part of the diet of many natives in India, China, Japan, other parts of Asia and Africa. In continental Europe it is an important article of commerce and is used for culinary purposes, as a salad oil, in the manufacture of margarine, and for soap making. In certain European countries it is obligatory to mix from 5 to 10% of sesame oil with margarine in order to facilitate the recognition of margarine, sesame oil being easily detected by color tests. Small annual importations of the oil have been made into the United States during the last ten or fifteen years. Recently these importations have been increasing. In this country the oil is used to a small extent in the manufacture of margarine, lard substitute, and soap.

The seed contains from 50 to 57% of oil. It is customary to make one or two pressings cold, followed by one hot. The first cold pressing produces the oil of the best quality. The hot-expressed oil is used chiefly for soap making. In some parts of China the seeds are roasted before being pressed. This process gives the oil a strong flavor and a dark color.

Practically no work on the composition of the oil is recorded in the literature.

The oil used in this investigation was cold pressed in the Oil, Fat and Wax Laboratory, by means of an expeller, from the yellow variety of seed grown in China and shipped from Hankow. The seed contained 55.1% of oil. The oil had a light yellow color and a slight, pleasant taste and odor.

Chemical and Physical Characteristics.—The more important characteristics are recorded in Table I. The percentages of saturated and unsaturated fatty acids were determined by the lead-salt-ether method and corrections were made for the small quantity of unsaturated acids that separate with the saturated acid fraction.[1] The percentage of unsaturated acids has also been corrected for the unsaponifiable matter, all of which separates with the unsaturated acid fraction. The iodine number of the unsaturated acid fraction containing the unsaponifiable matter was 129.0, and that of the unsaponifiable matter was 96.3. The iodine number of the pure unsaturated acids, therefore, is calculated to be 129.7.

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[1] THIS JOURNAL, **42**, 2398 (1920); *Cotton Oil Press*, **6**, No. 1, 41 (1922).

TABLE I

SESAME OIL

PHYSICAL AND CHEMICAL CHARACTERISTICS

d^{25}_{25}	0.9187	Polenske number	0.15
n^{20}	1.4731	Saturated acids (determined) (%) (iodine number 6.2)	12.8
Acid value	1.4	Unsat. acids plus unsaponifiable matter (determined) (%)	82.3
Iodine number (Hanus)	110.8	Iodine number of unsat. acids plus unsaponifiable matter	129.0
Saponification value	189.3	Iodine number of unsat. acids	129.7
Unsaponifiable matter (%) (iodine number 96.3)	1.73	Sat. acids (corrected) (%)	12.2
Acetyl value	9.8	Unsat. acids (corrected) (%)	81.2
Reichert-Meissl number	0.11		

Unsaturated Acids.—The bromine addition derivatives of the unsaturated acids were prepared.[2] No hexabromide was obtained, indicating the absence of linolenic acid. A large quantity of linolic tetrabromide (m. p., 114.0°), however, was obtained. Using the iodine number of the unsaturated acids (129.7) and the calculated iodine numbers of linolic acid (181.4) and oleic acid (90.1), there are obtained by calculation 43.4% of linolic acid and 56.6% of oleic acid in the unsaturated acid fraction, or 36.8% of linolic acid glyceride and 48.1% of oleic acid glyceride in the original oil.

Saturated Acids.—A quantity of the saturated acids prepared by the lead-salt-ether method was esterified with methyl alcohol.[3] This mixture of methyl esters was fractionally distilled under diminished pressure. The

TABLE II

SESAME OIL

FRACTIONAL DISTILLATION OF METHYL ESTERS OF SATURATED ACIDS

117.5 g. subjected to distillation

Distillation at, 7 mm. pressure				Distillation at 3 mm. pressure		
Fraction	Temp. °C.	Wt., G.		Fraction	Temp. °C.	Wt., G.
A	179–185	21.13	Fractions A and B distilled	1	152–153	12.10
B	185	21.30		2	154–159	23.77
C	186–189	22.95	Fraction C added	3	154–159	20.20
D	190–193	22.50	Fraction D added	4	159–164	22.35
E	194–199	21.60	Fraction E added	5	164–169	23.25
Residue		8.00	Residue added	6	170–181	12.00
				7	182–220	3.47
		117.48		Residue		0.21
						117.35

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[2] Lewkowitsch, "Chemical Technology and Analysis of Oils, Fats and Waxes," Macmillan Co., 6th ed., **1,** 579 (1921).

[3] THIS JOURNAL, **42,** 1200 (1920).

data for this distillation are given in Table II. By a preliminary distillation from a 1-liter Claisen flask the mixture was divided into 5 fractions (A, B, C, D, E) and a residue. These preliminary fractions were redistilled from a 250cc. Ladenburg flask according to the manner indicated in the table, and 7 fractions and a residue were obtained.

The iodine numbers, which are measures of the contaminating unsaturated acids and the saponification values of Fractions 1 to 7, are given in Cols. 2 and 3 of Table III. Using these data, the mean molecular weights of the saturated acid esters in each fraction were calculated as recorded in Col. 6.[4]

TABLE III

SESAME OIL

FRACTIONAL DISTILLATION OF METHYL ESTERS OF SATURATED ACIDS

Fraction	Iodine number	Saponification value	Mean molecular weight	Esters of unsaturated acids	Mean molecular weight of esters of saturated acids	Palmitic acid		Stearic acid		Arachidic acid		Lignoceric acid	
				%		%	G.	%	G.	%	G.	%	G.
1	2.5	207.1	270.9	2.04	270.5	92.22	11.16	0.67	0.08	...	..	...	..
2	3.3	204.3	275.3	2.69	274.1	79.79	18.97	12.54	2.98	...	..	...	..
3	4.9	202.7	276.8	3.99	276.1	72.24	14.59	18.89	3.82	...	..	...	..
4	6.6	199.4	281.3	5.37	280.6	56.84	12.70	33.05	7.39	...	..	...	..
5	9.7	193.0	290.7	7.90	290.2	25.48	5.92	62.17	14.45	...	..	...	..
6	9.0	186.6	300.6	7.33	300.9	...	...	80.43	9.65	7.92	0.95	...	..
7	9.0	170.1	329.8	7.33	332.7	...	...	...	...	78.73	2.73	10.03	0.35
							63.34		38.37		3.68		0.35

These results in Col. 6 indicate what acids may be present in the various fractions. The mean molecular weights of the saturated acid esters in Fractions 1 to 5 lie between the molecular weights of methyl palmitate (270.3) and methyl stearate (298.4), which indicates that these 5 fractions contain the two esters in varying proportions. The probable constituents of Fraction 6 are methyl stearate and methyl arachidate (326.4) and those of Fraction 7 are methyl arachidate and methyl lignocerate (382.5).

The free acids were recovered from some of these fractions by saponifying with alcoholic potash and decomposing the resulting soap with hydrochloric acid. The constituent acids were isolated by fractional crystallization from alcohol. Their identity was established by the melting points and by observing whether these melting points were lowered when the substances were mixed with equal quantities of the respective acids which they were suspected of being, the purity of which had been established previously by elementary analyses. In all cases the melting points of the isolated acids confirmed the deductions drawn from the mean molecular weights of the fractions. The following acids were isolated.

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[4] THIS JOURNAL, **42**, 152, 1197 (1920).

Lignoceric Acid ($C_{24}H_{48}O_2$).—After ten recrystallizations of the free acids recovered from Fraction 7, a crop of crystals which melted at 80° was obtained. The melting point remained unchanged when the substance was mixed with pure lignoceric acid.

Arachidic Acid ($C_{20}H_{40}O_2$) was also isolated from Fraction 7 and identified by the melting point, 77°.

Stearic Acid ($C_{18}H_{36}O_2$) was shown to be present in Fraction 6 by the melting point, 69°.

Palmitic Acid ($C_{16}H_{32}O_2$) was identified in Fraction 1 by the melting point, 63°.

No acid having a melting point lower than that of palmitic acid was found, although many recrystallizations were made of the acid recovered from Fraction 1.

This establishes the identity of the saturated acids in the various fractions. The quantities have been calculated from the mean molecular weights of the saturated acid esters (Col. 6, Table III) and the calculated molecular weights of the two esters in each fraction. The results are given in Cols. 7 to 14, Table III. The small residue, consisting mostly of decomposition products, was not taken into consideration.

In Table IV the percentage composition of the saturated acids is given in Col. 2, the percentages of saturated acids in the original oil in Col. 3, and the equivalent percentages of glycerides in Col. 4.

TABLE IV

SESAME OIL

SATURATED ACIDS

Acid	Acids in saturated acid fraction G.	%	Acids in original oil %	Glycerides in original oil %
Palmitic	63.34	59.90	7.31	7.7
Stearic	38.37	36.29	4.43	4.6
Arachidic	3.68	3.48	0.42	0.4
Lignoceric	0.35	0.33	0.04	0.0 (trace)
	105.74	100.00	12.20	12.7

Summary

The chemical composition of sesame oil has been determined with the following results.

Glycerides	%	Glycerides	%
Oleic	48.1	Arachidic	0.4
Linolic	36.8	Lignoceric, trace	(0.04)
Palmitic	7.7	Unsaponifiable matter	1.7
Stearic	4.6		

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