Chia Seed Oil

Contribution From Oil, Fat and Wax Laboratory Bureau of Chemistry and Soils, United States Department of Agriculture

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THE chia plant (*Salvia hispanica* L.), a shrub that reaches about five or six feet in height, is widely cultivated and grows wild in Mexico, where the seed is used for the preparation of a beverage that resembles "flax seed tea." Another species of the same genus (*Salvia columbariae* Benth.) grows in California, Nevada, Arizona and New Mexico.

A quantity of the seed of *Salvia hispanica* was obtained from Mexico by Henry A. Gardner[1]. The oil was expressed by means of an expeller in the writers' laboratory, and the yield after being filtered was a very clear oil of a light amber color.

Gardner and Holdt reported that the seed contained 33.8% of oil. They also determined the drying properties of the oil[2]. They found that the oil in the raw state dried rather slowly and exhibited pronounced "crawling" or tendency of the film to form drops. When a drier was added it dried as fast as linseed oil. The "crawling" tendency was practically overcome be heating the oil at 210° C. for fifteen minutes, and then the oil showed drying results even superior to linseed oil treated with the same amount of liquid drier. After heat treatment for bodying there was scarcely any change in color, which fact indicates that it would be suitable for light colored varnishes.

Some of the oil expressed for Mr. Gardner was used by the writers for the determination of its composition.

Chemical and Physical Characteristics

THE more important characteristics are reported in Table I. The iodine number is 5 to 10 points higher than the average figure. for linseed oils, and the hexabromide number[3] is about the same. The percentages of saturated and unsaturated acids were determined by the lead salt-ether method, and corrections were made for the small quantity of unsaturated acids that remains with the saturated acid fraction[4]. The percentage of unsaturated acids also has been corrected for the unsaponifiable matter, which separates with the unsaturated acid fraction.

Unsaturated Acids

THE composition of the unsaturated acids was calculated from the iodine number (190.0) and the thiocyanogen-iodine number (113.2) of the oil according to the Kaufmann method[5] which is based on the fact that linolenic acid quantitatively attaches thiocyanogen to two of its double bonds while linolic and oleic acids attach it to one double bond. The results from this calculation are given in Table II.

Table I

CHIA SEED OIL

Chemical and Physical Characteristics

Specific Gravity, 25°/25°	0.9358
Refractive index, 20°	1.4838
Acid value	1.4
Saponification value	194.8
Unsaponifiable matter (%)	0.7
Loss of weight when heated 3 hrs. at 110° C. in CO_2 atmos. (%)	0.3
Iodine number (Hanus)	190.0
Thiocyanogen-iodine number	113.2
Hexabromide number of total fatty acids	51.2
Saturated acids (corrected) (%)	8.1
Unsaturated acids (corrected) (%)	85.2
Iodine number of unsaturated acids	214.6

Table II

CHIA SEED OIL

Unsaturated Acids in Original Oil

	Acids %	Glycerides %
Linolenic	39.3	41.1
Linolic	45.2	47.2
Oleic	0.7	0.7
	85.2	89.0

The hexabromide number (51.2) is equivalent to 48.1% hexabromide for the oil and this in turn to 17.6% of Alpha—linolenic acid in the oil. The difference between this number and the total linolenic acid percentage is 21.7% and is considered to represent Beta—linolenic acid, which forms a liquid hexabromide.

The presence of oleic acid was determined by oxidizing a portion (30 grams) of the unsaturated acids with a dilute alkaline solution of $K_2Mn_2O_8$ at room temperature[6]. The dihydroxy acid was separated from the tetrahydroxy acid by dissolving it in ether. Although a large volume of ether was used only a small quantity of substance was dissolved. This was recrystallized four times from alcohol. Its melting point then was 130°. The melting point of 9-10 dihydroxy-stearic acid is 132°.

Saturated Acids

A QUANTITY of the saturated acids was separated from the oil by the lead salt-ether method and esterified with methyl alcohol[7]. The mixture of methyl esters was fractionally distilled under diminished pressure. The data for the distillation is given in Table III. A preliminary distillation from a 500cc. Claisen flask divided the mixture into four fractions and a residue. These preliminary fractions and the residue were redistilled from a 150 cc. Ladenburg flask according to the manner indicated in the table; five fractions and a small residue were obtained.

Table III

CHIA SEED OIL

Fractional Distillation of Methyl Esters of Saturated Acids

(77.55 g. subjected to distillation)

Preliminary distillation under 17 mm. pressure—

Fraction	Temperature °C.	Weight G.
A	203-5	20.30
B	205-6	23.80
C	207-12	21.20
D	213-30	9.50
Residue		2.75

Final distillation under 2 mm. pressure—

Fraction A and B added	1	155-7	6.25
	2	158-9	23.00
Fraction C added	3	160-4	23.25
Fraction D added	4	168-73	14.20
Residue added	5	185-210	9.80
	Residue		0.80

The iodine numbers and the saponification values of the five final fractions are recorded in columns 2 and 3, Table IV. The iodine numbers are measures of the contaminating unsaturated acids. From these data, the mean molecular weights of the saturated esters in each fraction were calculated, and the results are given in column 6[8]. The results in column 6 indicate what saturated acid esters may be present in the fractions. The figure for Fraction 1 lies between methyl-myristate (242.3) and methyl-palmitate (270.3) and indicates

Table IV

CHIA SEED OIL

Results of Analyses of Fractions Obtained by Distilling 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	Myristic Acid %	Myristic Acid Grams	Palmitic Acid %	Palmitic Acid Grams	Stearic Acid %	Stearic Acid Grams	Arachidic Acid %	Arachidic Acid Grams
1	3.3	211.8	264.9	1.61	264.5	19.20	1.20	73.97	4.62	11.07	2.55		
2	2.0	205.0	273.7	0.98	273.6			82.87	19.06	28.18	6.55		
3	4.6	201.0	279.1	2.25	278.8			64.65	15.03	60.51	8.59	25.85	2.53
4	7.0	194.2	288.9	3.42	288.8			31.28	4.44	65.51	6.42		0.40
5	8.7	183.5	305.7	4.25	306.3								
							1.20		43.15		24.11		2.93
Residue													

that this fraction consists of these two esters. The results for Fractions 2, 3 and 4 suggest mixtures of methyl palmitate and methyl stearate (298.4), while the probable constituents of Fraction 5 are methyl stearate and methyl arachidate (326.4).

These deductions were confirmed by recovering the free acids from some of the fractions and isolating them by fractional crystallization from alcohol. Their identities were established by their melting points and by observing whether or not 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.

Myristic acid ($C_{14}H_{28}O_2$) melting at 54°—55° C. and palmitic acid ($C_{16}H_{32}O_2$) melting at 63° C. were isolated from Fraction 1. From Fractions 2 and 4 were obtained palmitic acid and stearic acid ($C_{18}H_{36}O_2$) with a melting point of 69° C. A considerable quantity of arachidic acid ($C_{20}H_{40}O_2$) which melted 77° C. was crystallized frrom Fraction 5, and 0.40 gram of this acid was separated from the residue.

The quantities of the saturated acids in the fractions were calculated from the mean molecular weights of the esters (column 6, Table IV) and the theoretical molecular weights of the two esters in each fraction.

The percentage composition of the saturated acids is recorded in column 2, Table V. The percentages of saturated acids in the original oil are given in column 3, and the equivalent percentages of glycerides are furnished in column 4.

Table V
CHIA SEED OIL
Saturated Acids

	Acids in Saturated Acid Fraction Grams	%	Acids in Original Oil %	Glycerides in Original Oil %
Myristic	1.20	1.68	0.14	0.1
Palmitic	43.15	60.45	4.90	5.1
Stearic	24.11	33.77	2.73	2.9
Arachidic	2.93	4.10	0.33	0.3
	71.39	100.00	8.10	8.4

Summary

THE results of the determination of the chemical composition of chia seed oil are furnished below. The composition of two samples of linseed oil determined by Kaufmann and Keller[9] is given for comparison.

		%		Linseed Oil LaPlata %	Linseed Oil Calcutta %
Glycerides of	Linolenic	41.1		36.3	42.0
	Linolic	47.2		46.6	34.1
	Oleic	0.7		7.9	12.4
	Myristic	0.1	Saturated acid glycerides plus unsap. matter	8.6	10.8
	Palmitic	5.1			
	Stearic	2.9			
	Arachidic	0.3			
Unsaponifiable matter		0.7			
Loss of weight when heated 3 hours in CO_2 atmos.		0.3			

The chia seed oil contains a very small amount of oleic glyceride—much less than linseed oil, practically the same amount of linolenic glyceride as the Calcutta linseed oil, and more than the LaPlata linseed oil. One would expect its drying power, therefore, to be equal or somewhat superior to that of linseed oil.

[1] Educational Bureau, American Paint and Varnish Manufacturers' Association, Washington, D. C.

[2] H. A. Gardner and P. C. Holdt, Paint Manufacturers' Assoc. U. S .Bul. 105 (1920).

[3] Lawrence L. Steele and Frederick M. Washburn, Ind. Eng. Chem., 12, 52 (1920).

[4] J. Amer. Chem. Soc. 42, 2398 (1920); Cotton Oil Press, 6, No. 1, 41, (1922).

[5] H. P. Kaufmann and M. Keller, Z. Angew. Chec 42, 20 & 73, (1929).

[6] Lewkowitsch, "Chemical Technology and Analysis of Oils, Fats and Waxes," Macmillan Company, 6th ed., 1, 574, (1921).

[7] J. Amer. Chem. Soc. 42, 1200 (1920).

[8] J. Amer. Chem. Soc. 42, 152 and 1197 (1920).

[9] loc. cit.

The Roessler & Hasslacher Chemical Co. will be in its new quarters at 10 East 40th street, New York, on May 13; telephone Lexington 2550.

The Chicago sales offices of the Bisbee Linseed Co. have been moved to the mill at Main and Butler streets, Chicago Heights; telephone, Pullman 8757.