Oil Content and Composition of the Seed in the World Collection of Sesame Introductions[1]

D.M. YERMANOS, S. HEMSTREET, W. SALEEB and
C.K. HUSZAR, College of Biological and Agricultural Sciences,
University of California, Riverside, California 92502

ABSTRACT

The quantity and quality of oil was studied in 721 introductions of sesame seed. The mean oil content was 53.1% and the iodine value 117.4. The mean per cent fatty acid composition was: palmitic 9.5, stearic 4.4, oleic 39.6 and linoleic 46.0. The oil was clear, colorless in 47.4% of the samples and light green in 37.2%. The remainder of the oil samples were dark green or brown. Short plants tended to have colorless oil while tall plants had light green oil. Early plants had a higher seed oil content. Earliness, yellow seed color and large seed size were associated with lower iodine value. A significant negative correlation was found between oleic and linoleic acid content. There was no correlation between oil content and iodine value of the oil.

INTRODUCTION

Difficulties in harvesting dehiscent varieties of sesame and the low yields obtained from nonshattering varieties developed up to now have prevented sesame from becoming an established commercial crop in the U.S. The high quality of sesame oil and protein, however, and the possibility that sesame might be grown as an alternate crop in areas where cotton faces serious production problems have recently rekindled interest in the potential of sesame here and abroad.

All analytical data published to date on the quality of sesame oil have shown it to be an excellent and stable edible oil, free from any undesirable nutritional or flavor components. Because information on the existing variability of genetic materials available for breeding could prove valuable to plant geneticists, we undertook a study of the world collection of sesame introductions at the U.S. Department of Agriculture. Data obtained on fatty acid composition, iodine value, oil content and color, and associations between botanical and oil characteristics are presented in this report.

[1]One of seven papers presented at the Symposium, "The Plant Geneticist's Contribution Toward Changing the Lipid and Amino Acid Composition of Oilseeds," AOCS Meeting, Houston, May 1971.

TABLE I

Sesame Plant Introductions Studied

Country of origin	Number of samples	Country of origin	Number of samples
Turkey	154	Mexico	13
India	113	Afghanistan	12
Venezuela	58	Pakistan	11
China	49	Russia	11
Japan	40	Mozambique	10
Iran	26	Egypt	10
Israel	25	Australia	9
Sudan	21	Iraq	8
Colombia	14	Argentina	7
Greece	14	Others	116
		Total	721

EXPERIMENTAL PROCEDURE

The world collection of sesame introductions at the U.S. Department of Agriculture includes more than 900 seed samples from all over the world. Small amounts of original seed were received by the USDA, and then grown to increase the seed supply and permit observations of botanical characteristics. A list of 513 sesame introductions with corresponding descriptive data was published by Massey (1) in 1966. A major part of the world collection comprising 721 samples was made available to our laboratory (Table I) for oil content and composition determinations; botanical data were available on only 472 of these samples.

Oil content was determined by comparing the weight of approximately 2 g duplicate seed samples before and after oil removal by pressure and petroleum ether extraction. Iodine value of the oil was determined with a Bausch and Lomb Hand Refractemeter and also calculated from the fatty acid composition of oil samples as follows: iodine value = (% oleic acid x 89.9) + (% linoleic acid x 181.1) x 100. Fatty acid composition of triglycerides was determined by gas liquid chromatography of methyl esters prepared as described by Metcalf et al. (2). Two 6 ft x 1/8 in. aluminum columns packed with 10% HI-EFF on 100/120 mesh Chromosorb-W, acid-washed, were used for the ester analysis, on a GC-4 Beckman chromatograph equipped with flame ionization. Column temperature was isothermal at 170 C, detector 250 C and injector 225 C; hydrogen flow was 35 ml/min (each flame); helium 25 ml/min (each column), and air 250 ml/min.

RESULTS

The mean oil content, iodine value and fatty acid composition of the entire seed collection is shown in Table II. The five highest oil content values came from Turkey, Venezuela, Egypt and Afghanistan (58.6-59.8%). The five lowest values came from Venezuela, India, Japan and Afghanistan (40.4-47.2%). Among the 10 countries with 14 or more seed samples (Table III) the highest oil content (53.3-55.0%) was found in samples from the Mediterranean region (Iran, Israel, Greece). Samples from all 10 countries were fairly close in the upper limit of the range in oil content; in the lower limit, however, Venezuela and India had samples with much lower oil content (40.4% and 41.7%, respectively) than the other eight countries. In the two countries with the greatest number of samples, the frequency distribution of mean oil content values was skewed to the right of the general mean for Turkey (138 samples) and to the left for India (88 samples).

The highest mean iodine values (119.1-119.8) in this group of countries were found in samples from Colombia, Venezuela and the Sudan; the lowest (115.3-115.7) were in samples from Turkey, Israel and Greece (Table IV). The five highest iodine values came from the Philippines, India, Angola, Venezuela and Turkey (126-130). The five lowest values came from Japan, India and Turkey (106-110). Thus no geographic pattern could be established in the distribution of seed oil content and iodine value of the oil. Among countries with large numbers of samples, India had the largest range in iodine values, Turkey was intermediate,

TABLE II

Seed Oil Characteristics of 721 Sesame Plant Introductions

	Per cent oil	Iodine value	Fatty acids, %			
			Palmitic	Stearic	Oleic	Linoleic
Mean	53.1	117.4	9.5	4.4	39.6	46.0
Range	40.4-59.8	106-130	8.3-10.9	3.4-6.0	32.7-53.9	39.3-59.0

TABLE III

Mean Seed Oil Content in Countries with 14 or More Seed Samples

Country of origin	Number of samples	Per cent oil[a]	Range	Coefficient of variation
Iran	26	55.0 a	51.0-58.6	3.7
Israel	25	54.0 ab	49.6-57.9	3.6
Turkey	154	53.8 b	47.4-59.2	4.3
Venezuela	58	53.4 bc	40.4-58.9	5.7
Greece	14	53.3 abc	50.3-58.1	4.6
China	49	52.5 c	48.4-56.7	3.8
Colombia	14	52.5 bcd	47.7-57.7	6.1
India	113	51.4 d	41.7-54.7	4.1
Japan	40	51.1 d	47.0-54.6	3.8
Sudan	21	50.9 d	48.9-52.9	2.4
Total	514	52.8 Mean		

[a]Means followed by the same letter are not significantly different at the 1% level.

TABLE IV

Mean Iodine Value of Seed Oil in Countries with 14 or More Seed Samples

Country of origin	Number of samples	Per cent oil[a]	Range	Coefficient of variation
Colombia	14	119.8 a	115-124	2.0
Venezuela	58	119.5 a	112-127	2.4
Sudan	21	119.1 ab	115-123	1.6
Iran	26	117.8 bc	114-121	1.6
India	112	117.7 c	110-128	2.5
China	48	117.2 c	114-121	1.6
Japan	40	116.7 cd	106-123	2.8
Turkey	153	115.7 d	110-123	2.5
Israel	25	115.4 d	110-120	2.1
Greece	14	115.3 d	113-118	1.2
Total	511	117.4 Mean		

[a]Means followed by the same letter are not significantly different at the 1% level.

and China had a narrow range (18, 13 and 7 iodine value units, respectively).

The range in fatty acid composition of the oil was very broad (Table II). The five highest and five lowest values, respectively, for each of the fatty acids came from the following countries: (1) Palmitic acid: India, Greece, Turkey (10.7-10.9%); India, Israel, Venezuela (8.1-8.3%); (2) stearic acid: China, Australia, Mexico (5.8-6.0%); India, Turkey, Venezuela, Pakistan (3.1-3.4%); (3) oleic acid: China, Japan, Israel (45.8-53.9); Angola, Ethiopia, Phillippines, India (54.0-59.0%); China, Japan, Israel, Turkey (31.1-39.3%).

Of the 721 samples studied, 342 (or 47.4%) had a clear, colorless oil and 268 (37.2%) had a light green colored oil. The remainder of the oils were dark green or brown in color (Table V). Clear and light green were the predominant oil colors in the countries listed in Table V with the exception of Sudan, Iran and Israel, where colorless types of oil were rare.

The following botanical characteristics were correlated with seed oil characteristics (Table VI): (1) plant height and oil color: short plants had clear oil while tall plants had light green oil; (2) maturity and oil content: early plants had a higher oil content than medium and late plants; (3) maturity, seed color, seed size and iodine value: earliness, yellow seed color and large seed size were correlated with

TABLE V

Oil Color of Sesame Plant Introductions

	Color					
	Dark green	Light green	Clear	Light brown	Dark brown	Total
Number of samples in entire collection	24	268	342	81	6	721
Number of samples by country[a]						
Turkey	3	42	93	14	–	152
India	4	51	36	19	1	111
Venezuela	–	11	46	–	1	58
China	–	10	39	–	–	49
Japan	–	24	16	–	–	40
Iran	1	13	5	7	–	26
Israel	2	14	1	7	–	24
Sudan	8	1	–	9	3	21
Colombia	2	5	5	1	1	14
Greece	–	9	4	1	–	14
Total	20	180	245	58	6	509

[a]Countries with 14 or more samples.

TABLE VI

Association Between Botanical and Oil Characteristics

A. Oil Color–Plant Height

Oil color	No. of samples	Plant height, in.[a]	Coefficient of variation
Clear	207	47.0 b	34.7
Light brown	37	52.0 ab	33.8
Light green	136	54.1 a	30.3
Total	380 Mean	51.0	

[a]Means followed by the same letter are not significantly different at the 1% level.

B. Maturity–Oil Content

Maturity	No. of samples	Oil Content, %[a]	Coefficient of variation
Early	157	55.1 a	4.1
Medium	104	52.9 b	3.8
Late	91	53.0 b	4.0
Total	352 Mean	53.77	

[a]Means followed by the same letter are not significantly different at the 1% level.

C. Iodine Value–Maturity, Seed Size and Color

Association	No. of samples	Iodine value[a]	Coefficient of variation
Maturity-iodine value			
Early	156	115.7 c	2.4
Medium	104	116.9 b	2.0
Late	90	119.0 a	2.7
Total	350	117.2 Mean	
Seed color-iodine value			
Yellow	17	115.0 b	2.3
White	97	117.7 a	2.6
Black	34	118.0 a	3.0
Buff	11	119.1 a	1.0
Total	159	117.5 Mean	
Seed size-iodine value			
Small	45	118.7 a	3.4
Medium	243	116.8 b	2.5
Large	114	116.9 b	2.6
Total	402	117.5 Mean	

[a]Means followed by the same letter are not significantly different at the 1% level.

D. Oleic Acid Content–Maturity, Seed and Oil Color

Association	No. of samples	Oleic acid, %[a]	Coefficient of variation
Maturity–oleic acid content			
Early	157	40.9 a	5.8
Medium	104	40.5 a	5.9
Late	89	38.3 b	7.9
Total	350	39.9 Mean	
Seed color–oleic acid content			
Yellow	17	41.3 a	6.0
White	97	40.3 a	6.1
Tan	120	40.3 a	7.5
Brown	121	39.4 b	7.2
Black	34	38.9 b	8.4
Buff	11	36.6 c	4.0
Total	400	39.4 Mean	
Oil color–oleic acid content			
Clear	321	40.8 a	6.8
Light green	212	38.8 b	7.2
Light brown	61	37.7 c	7.3
Dark green	20	37.6 bc	6.6
Dark brown	6	36.7 bc	2.0
Total	620	38.3 Mean	

[a]Means followed by the same letter are not significantly different at the 1% level.

TABLE VII

Simple Correlations Among Oil Characteristics

Characteristic	Oil content	Iodine value, refractometer	Iodine value, calculated	Fatty acids, %			
				Palmitic	Stearic	Oleic	Linoleic
Plant height	-.19[a]	.42[a]	.28[a]	-.01	-.09	-.33[a]	.31[a]
Oil content		-.05	.05	-.06	-.05	-.08[b]	.07[b]
Iodine value, refractometer			.76[a]	-.27[a]	-.30[a]	-.68[a]	.67[a]
Iodine value, calculated				-.15[a]	-.58[a]	-.88[a]	.91[a]
Palmitic acid					-.07[b]	-.24[a]	.01
Stearic acid						.38[a]	-.51[a]
Oleic acid							-.95[a]

[a]Significant at .01 level.
[b]Significant at .05 level.

lower iodine values. Similarly, earliness and yellow seed color were correlated with high oleic and low linoleic acid content.

Simple correlations among oil characteristic are shown in Table VII. As with safflower oil, significant negative correlation between oleic and linoleic acid was found (3). Of special importance to plant breeding was the absence of a significant correlation between oil content and iodine value. A significant positive correlation between iodine value and oleic and linoleic acid content leads to the following regre,sion equations (based on 713 degrees of freedom):

y(linoleic acid %) = -322.5 + 6.7 x iodine value (st. error = 23.30)

y(oleic acid %) = 1152.4 - 6.4 x iodine value (st. error = 21.48)

Our study of seed oil content and composition in sesame shows that there is considerable quantitative variability of both traits in the world collection. However no strains were found with radically different composition or with any undesirable lipid component which might lower the quality of this edible oil. It should be pointed out that the samples analyzed were in many cases quite heterogeneous, representing local unselected populations, segregating populations, or mechanical mixtures. Thus single seed selections from the original samples might greatly expand the amount of variability.

REFERENCES

1. Massey, J.H., University of Georgia, Bull. N. S. 181 (1966).
2. Metcalf, L.O., A.A. Schmitz and J.R. Pelka, Annal. Chem. 38:514 (1966).
3. Yermanos, D.M., S. Hemstreet and M.J. Garber, Crop Sci. 7:417 (1967).

[Received July 10, 1971]