Protein and Oil Compositions of Sesame Seed

A.H. El TINAY, A.H. KHATTAB, and M.O. KHIDIR,
Faculty of Agriculture, University of Khartoum, Sudan

ABSTRACT

The range of protein in the oil-free meal and oil in 20 exotic varieties of sesame ranged from 45.0 to 53.7% and 42.2 to 52.1%, respectively; while in 26 local varieties, the ranges were 45.0 to 60.0% and 41.3 to 49.6%. The fatty acid composition showed only small variability. The local types have higher linoleic acid and lower oleic acid amounts than those of the introduced varieties. The amino acid levels of oil-free sesame meal prepared from both introduced and local varieties were examined. Nearly twofold variations in the limiting amino acids (lysine, isoleucine, methionine, threonine, and valine) were found. Utilization of these variations in amino acid composition should assist the development of sesame protein of improved quality.

INTRODUCTION

The world production of sesame (*Sesamum indicum* L.) seed is ca. 1,900,000 tons, and the principal producing countries are India, China, Sudan, and Mexico; Sudan is the main exporter. The seeds are used in confectionery and bakery products, but the most important use is for oil extraction. As early as 1927, Jones and Gerdorfe (1) reported that sesame seeds were rich in both protein and oil. Later, the studies of Chartfield (2) and Yermanos et al. (3) indicated that besides the high protein content of the seeds their nutritive value was also high and the amino acid composition was similar to that of meat. The utilization of oilseed meals as supplementary protein sources for human consumption has received considerable attention in recent years. One of the objectives of sesame breeding today is to increase the oil as well as the protein content of the seeds and to improve the quality of these important food components.

Air-dried sesame seed usually has an oil content between 44 and 54%, but oil contents as low as 35% and as high as 57% are known. Greater than 60% oil has been reported in Egypt (4) and in the USSR (5). The most outstanding characteristic of the oil is its stability, which is due to natural antioxidants. The chemical composition of sesame oil has been reviewed by Budowski and Markley (6) and by Johnson and Raymond (7).

The protein content of the sesame seed is usually between 19 and 25%, but higher and lower figures have been reported (8,9). The amino acid composition of sesame protein has been reviewed by Johnson and Raymond (7).

Kinman and Stark (10) reported that the chemical composition of seeds was affected not only by genotype but also by agro-climatic conditions. Keeping this in view, the objective of the present work was to establish the chemical variability between 20 introduced and 26 local types of sesame seed. Such information is valuable for genetic improvement of sesame seed as well as a basis for nutritional evaluation of sesame meal.

MATERIALS AND METHODS

Twenty exotic and 26 local strains of sesame were grown on a heavy clay soil in the Demonstration Farm, Faculty of Agriculture, Shambat, in 1974. These strains represented a wide range of types differeing in maturity, height, degree of branching, and other characteristics (Tables I and II). They were planted on ridges 75 cm apart and 15 cm between plants along the ridge. Watering was at 2-week intervals, and no fertilizer was applied. Seed samples were obtained from each strain and were carefully cleaned to remove foreign material.

Total oil was determined by extracting the ground seeds in a soxhlet apparatus with petroleum ether for 12 hr. The oils were hydrolyzed with 0.5 N methanolic NaOH in a steam bath. The free fatty acids were converted to methyl esters by the BF_3-methanol procedure of Metcalfe et al. (11), and the esters analyzed by gas liquid chromatography on a Varian Aerogram Model 2100 Chromatograph equipped with ionization detectors held at 250 C. A 1.5 meter x 4 mm column packed with diethylene glycol succinate on Universal support (100-120 messh) was used at 200 C. The identification and the molar ratios of the fatty

TABLE I

Name, Origin, and Seed Color of the 20 Introduced Sesames

Number					
Code	FAO	Name	Origin	Seed color	Remarks
K 3	23.813	L.55-107-3	USA	Light brown	4-6 locules/pod
K 8	23.818	Margo	USA	Light brown	–
K 12	23.822	Kansas 8-1-1-1-18	USA	Light brown	–
K 32	23.842	641A	Palestine	Brown and white	–
K 40	23.840	D-E	Portugal	Greyish white	–
K 42	23.852	Fethiye-1	Turkey	Brown and light brown	Very early
K 63	23.873	Zentsuji-	Japan	Brown	–
K 70	23.880	Bulgarien	Bulgaria	White and brown	–
K 71	23.881	Andong	Korea	White and brown	–
K 74	23.884	Machis-61-dulce	Brazil	Drak grey and white	–
K 81	23.891	P-S-T.12-24	India	White	Small seeds
K 82	23.892	Tilm 2-3	India	Drak grey	–
K 105	23.915	Acarigua	Venezuela	Greyish white	–
K 108	23.918	Local kelafforeg	Ethiopia	Light brown	–
K 112	23.922	–	Tanzania	Greish white	Very late
K 138	23.948	Taiwan black 2	China	Black	8 locules/pod
K 141	–	Baco	USA	Brown	Indehiscent
K 143	–	Giza 24	Eqypt	White	–
K 147	–	14/12	Eqypt	Light brown	–
K 154	–	68 - 1181	Venezuela	Light brown	Long pods

TABLE II

Name and Seed Color of 26 Local Sesames

Number		Name			
Code	Collection	Original	New	Seed Color	Remarks
M 2	A/1/2	Fung white	Ziraa 3	White	–
M 3	A/1/3	Gedaref type	Ziraa 2	White	–
M 4	A/1/4	Amortaba	Ziraa 10	White	8 locules/pod
M 5	A/1/5	Goam	Ziraa 7	White	–
M 9	A/1/9	Quarein light	Ziraa 9	White	Uneven maturity
M 10	A/1/10	Quarein late light	Ziraa 1	White	Uneven maturity
M 16	A/2/5	Cheparaida	Ziraa 28	Dirty white	–
M 21	A/2/10	Heavy Qual El Nahal	Ziraa 26	Dirty white	–
M 22	A/2/11	Kordufan white	Ziraa 37	Dirty white	–
M 23	A/2/12	Kadugli type	Ziraa 41	Dirty white	8 locules/pod
M 25	A/2/14	Mass selection early resistant white	Ziraa 34	Dirty white	–
M 31	A/3/1	Annek	Ziraa 79	Grey white	Small seeds
M 34	A/3/4	Lodengo long	Ziraa 82	Grey white	Small seeds
M 41	A/4/2	Gadaref type	Huria 11	Light brown	–
M 44	A/4/5	Goam	Huria 2	Light brown	–
M 48	A/4/9	Mafaza light	Huria 1	Light brown	–
M 51	A/5/1	Baladi asfar	Huria 33	Brown	–
M 58	A/5/8	Naradie el lebu	Huria 42	Brown	–
M 62	A/5/12	Un Hireihir 57	Huria 45	Brown	–
M 63	A/5/13	Wad El Neil heavy black	Huria 31	Brown	–
M 67	A/5/17	Um Ruaba	Huria 48	Brown	–
M 73	A/6/4	Darfur local red	Huria 75	Dark brown	–
M 76	A/7/1	Um Hereihir 54	Tozi 1	Light grey	–
M 83	A/8/5	Mawang	Tozi 35	Grey	–
M 85	A/9/1	Azrag	Tozi 73	Dark grey	–
M 90	A/10/1	Hindi	Aswad	Black	–

TABLE III

Oil Percengage, Oil Composition, and Iodine Value of 20 Exotic Types of Sesame Grown at Shambat in 1974

		Fatty acid composition of oil (%)				
Variety	Oil (%)	C 16	C 18	C18:1	C18:2	Iodine value[a]
K 3	48.1	9.6	5.1	42.5	42.8	110.7
K 8	47.7	8.7	4.5	46.2	43.7	115.5
K 12	49.1	8.7	6.9	45.8	38.7	106.4
K 32	48.0	10.0	4.4	45.5	40.0	108.0
K 40	44.6	8.4	4.3	50.5	36.8	107.1
K 42	46.1	9.5	5.0	44.8	40.7	109.1
K 63	46.6	8.6	5.2	41.3	45.0	113.4
K 70	42.2	10.7	6.2	41.7	41.4	107.6
K 71	47.6	8.5	3.6	43.4	44.4	114.2
K 74	47.4	8.6	4.4	43.7	43.3	112.5
K 81	44.0	8.5	5.3	46.1	40.2	109.2
K 82	44.0	9.6	4.6	41.1	44.8	112.9
K 105	46.6	10.9	2.6	42.6	43.9	112.8
K 108	48.9	9.7	4.9	42.4	43.0	109.0
K 112	48.5	9.8	5.0	42.5	42.7	110.5
K 138	46.3	7.2	6.8	46.0	40.1	109.0
K 141	47.2	8.8	5.6	47.8	37.9	106.4
K 143	46.9	9.0	4.8	48.0	38.2	107.4
K 147	52.2	9.6	5.3	42.6	42.5	110.3
K 154	46.1	8.7	4.2	43.0	44.1	113.2
Range	42.2-52.2	7.2-10.9	2.6-6.9	41.1-50.5	36.8-45.0	106.4-115.5
Mean	46.9	9.0	4.9	44.4	41.7	110.3
SE(±)	1.02	0.17	0.23	0.57	0.56	0.57

[a]Calculated from gas liquid crhomatographic analysis.

acids were determined by reference to a standard of a known composition.

Nitrogen content determinations were made on fat-free meals by the microkjeldahl technique (12). The acid hydrolysis of the meal protein was carried out with 0.2 g sample, which was hydrolyzed with 3 ml of 6 N HCl in evacuated sealed tubes for 24 hr. Determination of the amino acid composition of the hydrolysates was carried out with the aid of a Technicon Automatic Amino Acid Autoanalyzer.

RESULTS AND DISCUSSION

Data for oil content, fatty acid composition, and iodine value of the different varieties of sesame seeds are presented in Tables III and IV. The ranges in oil content were 42.2 to 52.2% in the introduced varieties and 41.3 to 49.6% in the local varieties. The range of values obtained for oil were higher than those reported by Dhawan et al. (13). The major fatty acids were oleic and linoleic, which occur in approximately equal amounts and account for 86% of the fatty acids. It is noteworthy that linoleic acid is higher than oleic in the local types, and the reverse was true for the exotic types. The range for oleic acid was 41.1-50.5% and for linoleic acid 36.8-45.0% in the introduced varieties, and 36.9-45.0% for oleic and 40.5-49.1% for linoleic in the local varieties. There was 7.2-10.9% palmitic acid in the introduced varieties and 7.6-12.3% in the local ones. Stearic

TABLE IV

Oil Percengage, Oil Composition, and Iodine Value of 26 Local Types of Sesame Grown at Shambat in 1974

Variety	Oil (%)	Fatty acid somposition of oil (%) C 16	C 18	C18:1	C18:2	Iodine value[a]
M 2	48.3	7.6	5.5	41.5	45.4	114.3
M 3	41.3	10.2	5.5	43.2	41.1	108.3
M 4	47.3	10.0	4.9	39.4	45.8	113.2
M 5	48.3	10.1	5.1	42.5	42.3	109.8
M 9	47.7	9.8	3.8	41.0	45.5	114.0
M 10	42.2	9.9	5.4	39.8	44.9	112.0
M 16	45.0	12.3	5.3	36.9	45.5	110.6
M 21	49.0	8.8	4.3	40.0	46.9	115.7
M 22	48.5	10.8	4.7	43.4	41.1	108.5
M 23	49.6	9.7	4.6	45.1	40.5	108.9
M 23	46.9	8.2	4.8	42.7	44.3	113.5
M 31	46.4	8.9	4.5	42.4	44.2	113.0
M 34	47.1	9.4	3.5	8.0	49.1	117.7
M 41	45.1	10.0	4.6	38.3	47.2	114.6
M 44	49.5	9.4	3.8	45.0	41.8	111.0
M 48	47.0	9.1	5.2	38.7	47.0	114.7
M 51	44.5	11.7	5.2	41.3	41.9	108.0
M 58	45.3	9.8	5.2	40.8	44.2	111.6
M 62	45.0	10.1	4.4	42.1	43.3	111.3
M 63	47.4	8.4	4.5	43.6	43.6	113.0
M 67	45.7	9.4	4.5	42.3	43.8	112.3
M 73	44.5	9.5	4.6	44.3	41.6	110.2
M 76	42.4	9.4	5.4	40.4	44.8	112.4
M 83	47.4	9.4	4.3	38.7	47.7	115.8
M 85	48.6	10.2	5.7	40.4	43.7	110.4
M 90	45.4	11.11	4.6	38.1	46.2	112.8
Range	41.3-49.6	7.6-12.3	3.5-5.7	36.9-45.0	40.5-49.1	108.0-117.7
Mean	46.4	9.7	4.8	41.2	44.4	112.2
SE(±)	0.44	0.20	0.11	0.44	0.45	0.49

[a]Calculated from gas liquid chromatographic analysis.

acid ranged from 2.6 to 6.9% in the introduced varieties and from 3.5 to 5.7% in the local varieties. The amounts of all the fatty acids fell within the Codex ranges.

Since the varieties were grown in the same season and received similar husbandry practices and since bulk samples were used, it is safe to assume that environmental variables were eliminated and that the observed differences were due to the direct influence of genotype. Therefore, it may be possible to breed for higher or lower amounts of a specific fatty acid. M 16, an early maturing local type, had relatively high palmitic acid content (12.3%) and low oleic acid (36.9%).

The iodine value varied from 106.4 to 115.5 in the introduced varieties and from 108.0 at 117.7 in the local varieties. This small difference is a reflection of the differences of the relative amounts of linoleic and oleic acids in the two groups. Kinetic work on the oxidation of fatty acids revealed a greater rate of autoxidation of linoleic acid than oleic acid derivatives (14). There appears to be no correlation between the oil content of the seed and its iodine number. Similar observations have been made by Gupta et al. (15) in their study of linseed varieties.

Total protein and amino acid content of the introduced and local varieties are summarized in Tables V and VI. The total protein content (of oil-free residue) varied from 45.0 to 53.7% in the introduced varieties and from 45.0 to 60.0% in the local varieties. The protein of sesame seed is rich in glutamic acid and arginine. The methionine content for both introduced and local varieties was lower than the values of the FAO Reference Protein (16). This is also true for isoleucine. Lysine is deficient in all varieties except the variety K 154, which contained 4.22 g/16 g N which is equal to the value in the FAO Reference Protein (16). All the varieties with relatively high lysine content have dark seed coats. Of the essential amino acids, lysine, isoleucine, methionine, threonine, and valine showed considerable variability in both introduced and local types, with the variety K 154 excelling all the introduced and local varieties. Selection within this variety as well as in its hybrid progeny with the local types is in progress (Khidir, unpublished data). For histidine and arginine, which are essential for young chicks, only arginine showed considerable variability, with K 154 and M 51 excelling all the others.

The percentages of some of the amino acids reported earlier (3), for unspecified varieties of sesame, were outside the ranges of values reported here; yet the amino acid patterns were generally the same. The differences in amino acids among varieties were large enough to be of interest to plant breeders attempting to increase any of these five essential amino acids.

Many workers studied the relationship between seed coat color and seed composition. Hildebrandt (17), Singh (18), and Kawanishi (19) reported that the lighter colors contained higher oil contents. On the other hand, Hill (20) and Parthasarathy and Kedharnath (21) stated that black and brown seeds contained more oil but the oil from the white seeds was superior in quality. These contradicting claims are not substantiated by the present findings since it seems that there was no relationship between seed color and oil content or quality. Similarly, the present study is at variance with those of Singh (18), Krishnamurthy (22), and Krishnamurthy et al. (23), who reported that the protein content was highest in black seed followed by brown and white types in a descending order.

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TABLE V

Protein and Amino Acid Composition of Introduced Sesame

Variety	Protein (%)	g amino acid/16 g nitrogen															
		Aspartic	Threonine	Serine	Glutamic	Glycine	Alanine	Cystine	Valine	Methionine	Isoleucine	Leucine	Tyrosine	Phenyalanine	Histidine	Lysine	Arginine
K 8	52.5	3.4	1.9	2.5	9.9	2.6	2.1	0.7	1.5	0.8	1.4	3.2	1.5	2.2	1.2	1.1	5.2
K 12	51.2	3.6	1.4	2.8	9.7	2.7	2.2	0.7	1.7	0.4	1.4	3.2	1.4	2.3	1.2	1.2	5.2
K 32	45.0	3.9	1.9	2.7	9.9	2.5	2.4	0.7	2.0	0.6	1.6	3.4	1.4	2.3	0.9	1.3	5.4
K 40	46.2	5.6	2.7	4.2	13.7	3.7	3.3	1.0	3.2	1.0	2.3	5.0	2.1	3.3	1.6	2.0	8.0
K 42	45.0	4.4	1.9	3.3	12.0	3.0	2.8	0.9	2.3	0.8	2.0	4.1	1.8	2.7	1.2	1.0	6.4
K 63	51.2	5.7	2.8	4.3	15.9	4.1	3.9	1.4	3.1	1.0	2.5	5.5	2.4	3.8	1.5	1.9	8.7
K 70	52.5	4.5	2.2	3.4	12.2	3.2	3.0	1.2	2.5	0.9	2.0	4.4.	2.1	3.1	1.3	1.7	6.7
K 71	52.5	3.9	1.9	3.0	10.9	2.7	3.6		2.3	0.8	1.6	3.5	0.8	1.9	1.5	1.8	4.3
K 74	53.7	4.3	2.0	3.1	11.7	3.1	3.8		2.2	0.8	1.8	4.1	2.1	2.9	1.1	1.5	5.4
K 81	53.7	4.9	2.1	3.5	13.1	3.5	4.0		2.3	0.9	1.8	4.4	2.2	3.2	1.2	2.8	8.1
K 82	45.0	5.4	2.3	3.8	14.4	3.8	4.6		2.8	1.0	2.2	5.0	2.2	3.5	1.4	3.0	9.3
K 105	51.2	5.0	2.4	3.6	10.6	3.7	3.6	0.6	5.6	0.4	2.1	4.8	2.3	5.2	1.5	1.5	6.4
K 108	46.2	4.5	2.0	3.2	9.5	3.2	3.5	0.5	6.1	0.5	1.8	4.1	1.8	5.6	1.3	1.4	6.9
K 112	46.2	4.2	2.0	3.1	10.8	2.8	3.7		2.3	0.5	1.8	3.8	1.7	2.4	0.0	1.4	6.7
K 138	52.5	4.8	2.3	3.6	12.6	3.3	4.3		2.6	0.8	2.0	4.4	1.9	2.8	1.3	3.3	7.8
K 151	52.5	4.4	2.0	3.2	11.4	2.8	3.8		2.4	0.6	1.8	4.3	1.6	2.6	1.3	3.2	7.1
K 143	50.0	3.8	2.0	2.9	10.0	2.7	3.3		2.2	0.5	1.8	3.6	1.6	2.5	1.4	2.4	6.2
K 147	50.0	4.3	2.1	3.0	11.8	2.9	2.9	0.9	2.4	0.6	1.9	3.9	1.6	2.5	0.9	2.7	6.7
K 154	53.7	6.4	3.3	5.0	16.9	4.4	4.7	1.5	3.8	0.8	3.0	6.3	2.7	4.2	1.4	4.2	10.5
Range	45.0-53.7	3.4-6.4	1.4-3.3	2.5-5.0	9.5-16.9	2.5-4.4	2.1-4.7	0.5-1.5	1.5-6.1	0.4-1.0	1.4-3.0	3.2-6.3	0.8-2.7	1.9-5.6	0.9-1.6	1.0-4.2	4.3-10.5
Mean	50.3	4.6	2.2	3.4	11.9	3.2	3.4	0.9	2.8	0.7	1.9	4.3	1.9	3.1	1.3	2.0	6.9
SE(±)	00.76	0.16	0.09	0.14	0.48	0.13	0.11	0.09	0.27	0.05	0.08	0.18	0.10	0.23	0.04	0.21	0.36

TABLE VI

Protein and Amino Acid Composition of Local Sesame

Variety	Protein (%)	g amino acid/16 g nitrogen															
		Asparatic	Threonine	Serine	Glutamic	Glycine	Alanine	Cystine	Valine	Methionine	Isoleucine	Leucine	Tyrosine	Phenyalanine	Histidine	Lysine	Arginine
M 5	45.0	5.3	2.4	3.7	14.4	3.8	3.2	0.4	1.5	1.1	2.0	4.9	2.3	3.4	1.7	1.6	7.8
M 9	52.5	4.3	2.1	3.1	12.2	3.2	2.7	0.9	1.9	0.4	1.6	4.0	2.0	2.7	1.3	1.4	6.5
M 10	55.0	4.8	2.3	3.6	13.3	3.6	3.1	1.2	2.4	1.2	2.1	4.6	2.3	3.2	1.5	1.6	7.7
M 16	52.5	5.1	2.3	3.6	13.8	3.7	3.0	0.9	2.3	1.0	2.0	4.5	2.1	3.1	1.5	1.7	7.5
M 21	52.5	4.9	1.8	3.6	13.2	3.8	3.0	0.9	1.5	1.0	1.3	4.0	2.3	2.7	1.5	1.2	6.7
M 22	55.0	4.2	2.0	3.0	11.5	3.1	2.5	1.0	1.9	0.8	1.6	3.8	1.8	2.1	1.2	1.4	6.3
M 23	53.7	4.3	1.9	2.9	11.7	310	2.4	0.9	1.8	0.8	1.5	3.7	1.7	2.1	1.3	1.4	6.1
M 25	57.5	5.0	2.5	3.7	12.9	3.7	3.1	1.0	2.4	1.0	2.0	4.7	2.2	3.3	1.5	1.6	7.8
M 31	52.5	4.1	2.0	3.1	11.1	2.7	2.6	0.7	2.1	0.8	1.8	3.8	1.6	2.5	1.2	1.3	6.0
M 34	47.5	5.0	2.4	3.7	13.4	3.3	3.2	0.9	2.6	1.1	2.2	3.4	2.0	3.1	1.5	1.8	7.4
M 41	48.7	4.2	2.0	3.1	10.9	2.8	2.7	0.9	2.3	0.7	1.8	3.9	1.8	2.6	1.1	1.5	6.2
M 44	48.7	4.4	2.0	3.2	11.5	3.9	2.7	1.0	2.0	0.8	1.1	3.9	1.7	2.7	1.1	1.4	6.2
M 48	52.5	4.1	2.0	3.4	10.9	2.8	2.7	1.0	2.0	0.7	1.7	3.6	1.8	2.6	1.0	1.4	6.2
M 51	50.0	6.5	3.3	5.1	15.4	4.6	4.5	1.5	3.7	1.0	3.0	6.5	2.6	4.3	1.9	2.4	10.4
M 58	51.2	5.0	2.2	3.4	13.1	3.2	3.0	0.9	2.7	1.1	2.3	4.5	1.9	3.0	1.2	1.5	7.2
M 63	55.0	4.2	1.9	3.0	10.9	2.8	3.5	0.4	3.5	0.5	1.1	5.4	1.8	3.8	1.7	1.4	5.8
M 67	57.5	4.0	2.0	3.2	11.6	2.9	2.8	1.1	2.2	0.8	1.8	4.1	1.9	2.8	1.1	1.3	6.4
M 73	60.0	4.3	2.0	3.0	11.9	3.1	2.9	1.1	2.2	0.8	1.8	4.0	1.8	2.8	1.1	1.3	5.9
M 76	56.2	4.7	2.1	3.3	12.8	3.2	3.2	1.2	2.4	0.9	1.9	4.3	1.9	3.0	1.3	2.2	6.6
M 83	50.0	4.7	2.2	3.5	12.4	3.2	4.3		2.5	0.8	2.0	4.3	1.7	2.7	1.5	2.5	7.6
M 85	51.2	4.6	2.3	3.4	12.0	3.0	4.2		2.5	0.7	2.0	4.0	1.5	2.7	1.3	3.3	7.7
M 90	51.2	4.3	2.1	3.2	11.5	2.9	4.0	0.5	2.4	0.7	1.9	4.0	1.7	2.6	1.5	3.0	7.2
Range	45.0-60.0	4.0-6.5	1.8-3.3	2.9-5.1	10.9-15.4	2.7-4.5	3.4-4.5	0.4-1.5	1.4-3.7	0.4-1.2	1.0-3.0	3.4-6.5	1.5-2.6	2.7-4.3	1.0-1.9	1.2-3.3	5.8-10.4
Mean	53.4	4.7	2.2	3.4	12.4	3.3	3.1	0.9	2.2	0.8	1.8	4.3	1.9	2.9	1.4	1.7	7.0
SE(±)	0.76	0.08	0.04	0.10	0.26	0.10	0.13	0.06	0.11	0.04	0.09	0.14	0.06	0.11	0.05	0.12	0.22

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