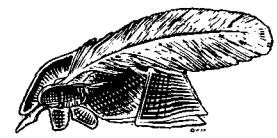
Technical



Lipid Composition of Selected Vegetable Oils[1]

DOROTHY L. CARPENTER, JOANNA LEHMANN, BLANCHE S. MASON[2] and HAL T. SLOVER, Lipid Nutrition Laboratory, Nutrition Institute, ARS, USDA, Beltsville, Maryland 20705

ABSTRACT

This paper gives analytical data on the composition of 14 selected consumer-available liquid vegetable oils, including soybean, soybean-cottonseed blends, corn, safflower, peanut, olive and apricot kernel oils. Label information identified six samples as specially processed or refined and three samples as cold pressed with no preservative added; the labels of the remaining five samples did not mention processing. Data are given for fatty acid composition, *trans* content, location of the double bonds in the unsaturated fatty acids, percent conjugation, tocopherol content, fatty acid composition of the 2-poisition of the triglycerides, polyunsaturated to saturated fatty acid (P/S) ratio, and the ratio of α-tocopherol to polyunsaturated fatty acids (α-T/P). The ranges of values found were: conjugated unsaturation, 0.18-1.09%; α-tocopherol, 0.01-0.60 mg/gm; total tocopherol 0.14-1.52 mg/gm; P/S, 0.5-8.7; and α-TP, 0.03-2.26. The compositions of the fatty acids on the 2-position and on the 1,3-position of the triglycerides were compared with those calculated by the Evans' hypothesis and found to agree well for all but olive and apricot kernel oils.

INTRODUCTION

The consumption of vegetable oils in the form of salad or cooking oils has increased dramatically in recent years (1). In the period 1947-49, liquid vegetable oils comprised 6.5% of all fat consumed in the United States. By 1973, this usage had risen to 16.3%, and oils were second only to the meat, poultry, and fish groups as sources of dietary fat; vegetable margarine and shortening contributed only 6.8 and 10.0%, respectively (1). Since vegetable oils have a major role in providing dietary polyunsaturated fatty acids, it is desirable that the composition and structure of these oils be adequately described to provide basic information to nutritionists and others concerned with the use and investigation of dietary fat. This need is particularly acute for products directly available to the consumer.

This report gives detailed information on the fatty acid composition, positional and geometrical isomers of the total fatty acids of the triglycerides, the identities and structures of the fatty acids at the 2-position of the triglycerides, and the tocopherol composition of a group of 14 consumer-available oils. This is part of a continuing effort to provide information on the major food fats regarding lipid compositional features of known or suspected nutritional significance (2).

MATERIALS

The 14 oils were bought in retail stores in the Washington, D.C., area on May 19, 1972. They included both national and private or store brands of seven different seed oils (Table I). The label information designated six of the oils as "Specially Processed" or "Specially Refined" and three as "Cold Pressed." Labels on the remaining five oils gave no information about processing. An effort was made to include the more popular oils; hence a greater number of samples containing soybean oil were selected. The three

[1]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

[2]Deceased

TABLE I

Description of Oils Analyzed

Brand	Where Bought[a]	Oil used	Processing	Additives
Wesson	A	Soybean oil Cottonseed oil	Specially processed	Polyglycerols
Nu-Made	A	Soybean oil Cottonseed oil	Specially processed	BHA, BHT, methyl silicone
Giant	A	Soybean oil	Specially processed	Methyl silicone, oxystearin, BHA, BHT
Crisco	A	Soybean oil	Specially processed	BHA, BHT, polysorbate, polyglycerol, methyl silicone
Kraft	A	Soybean oil	Specially processed	Oxystearin, BHA, BHT, methyl silicone
Hollywood	A	Soybean oil	Cold pressed	None
Ann Page	A	Corn oil	Specially processed	No information
Nu-Made	A	Corn oil	No information	No information
Mazola	A	Corn oil	No information	Isopropyl citrate, methyl silicone
Saffola	A	Safflower oil	No information	Citric acid, propyl gallate
Hollywood	A	Safflower oil	Cold pressed	None
Planters	A	Peanut oil	No information	No information
Progresso	A	Olive oil	No information	No information
Golden Harvest	B	Apricot kernel oil	Cold pressed	None

[a]A = Suburban supermarket; B = small suburban health food store

TABLE II

Fatty Acid Composition of Food Oils

Oil	14:0	16:0	16:1	18:0	18:1	Unknown	18:2	Unknown	18:3	20:0	20:1	22:0	24:0
	Weight percent of total fatty acid methyl esters												
Wesson SBO/CSO	0.1	12.1	0.1	4.2	33.4	Tr.	46.7	–	3.0	0.3	–	0.1	–
Nu-Made SBO/CSO	0.1	10.8	0.2	5.0	35.0	0.1	44.1	–	3.4	0.3	–	0.2	–
Giant SBO	Tr.[b]	10.1	–	4.8	40.8	0.1	40.8	0.2	2.7	0.3	Tr.	0.2	–
Crisco SBO	Tr.	8.9	–	3.9	47.2	0.1	36.7	0.2	2.7	0.3	Tr.	0.2	–
Kraft SBO	Tr.	10.0	–	5.0	45.8	0.1	36.6	0.4	2.0	–	–	0.2	–
Hollywood SBO	Tr.	10.6	–	4.1	24.7	–	52.6	–	7.6	0.3	–	0.2	–
Ann Page CO	–	11.4	–	2.2	26.1	–	58.5	–	1.4	0.4	0.2	–	–
Nu-Made CO	–	11.3	–	2.2	26.4	–	58.3	–	1.2	0.4	0.1	–	–
Mazola CO	–	11.5	–	1.8	25.1	–	60.5	–	0.6	0.4	Tr.	–	–
Saffola SFO	0.1	6.4	–	2.3	11.6	–	79.3	–	–	0.3	–	–	–
Hollywood SFO	0.1	6.5	–	2.4	11.2	–	79.5	–	–	0.2	–	–	–
Planters PO	–	10.2	–	2.4	47.1	–	33.2	–	–	1.3	1.1	3.1	1.5
Progresso OO	–	10.5	0.8	3.1	78.6	–	6.2	–	0.5	0.3	Tr.	–	–
Golden Harvest AKO	–	5.2	0.8	1.2	58.7	–	33.4	–	0.7	–	–	–	–

[a]Soybean oil = SBO; Cottonseed oil = CSO; Corn oil = CO; Safflower oil = SFO; Peanut oil = PO; Olive oil = OO; Apricot kernel oil = AKO
[b]Tr. = Trace (<0.1%)

cold pressed oils were included because of the growing popularity of "natural" or unprocessed foods. Apricot kernel oil is one of the specialty oils for which there is limited compositional data.

The samples were stored under nitrogen at −40 C until used.

METHODS

Fatty Acids

The fatty acid composition was determined by gas liquid chromatography (GLC) on 10 ft x 1/8 in. glass columns packed with 10% EGS on 100/120 mesh Gas Chrom Q (Applied Science Laboratories, Inc., State College, PA), held at a column temperature of 150 C. Methyl esters were prepared by transesterification with BF_3/methanol (3). Peak areas were measured with an electronic integrator. Peak identities and quantitative accuracy were determined from known standards for each fatty acid reported.

Trans-unsaturation

Relative amounts of the *cis* and *trans* geometric isomers were determined by a combination of silver nitrate thin layer chromatography (TLC) (4) and GLC. Methyl esters prepared by transesterification with BF_3/methanol (3) were separated on Silica Gel G containing 5% $AgNO_3$ (Analtech, Inc., Newark, DE) with petroleum ether/diethyl ether (95/5 V/V) as the developing solvent. The plates were air-dried, sprayed with 2,7-dichlorofluorescein (0.1% in ethanol) and viewed under UV light. The principal zones in order of decreasing Rf values were the saturated, *trans* monoene, *cis* monoene plus *trans-trans* diene, *cis-trans* plus *trans-cis* diene, and *cis-cis* diene esters. The unsaturated zones were scraped from the plates and treated with chloride ion to break up the silver ion complex (5). The methyl esters were eluted with diethyl ether, freed of solvent in a stream of nitrogen, dissolved in isooctane, mixed with methyl heptadecanoate as a qualitative and quantitative internal standard, and analyzed by GLC as described above.

Positional Isomers

The positional isomers of the monoene fatty acids were determined by the ozonolysis method described earlier (2), with minor modifications. These modifications were the use of CS_2 as a solvent during ozonolysis and the reduction of the ozonides with triphenylphosphine (TPP). It was necessary to divert the TPP from the analytical column by means of a pre-column and a switching valve. Due to its toxicity, TPP must be vented through an adequate hood.

Conjugation

The percentage of conjugated double bonds was determined spectrophotometrically by AOCS Official Method Cd 7-58 (6).

Peroxide Value

The peroxide value was determined by AOCS Official Method Cd 8-53 (6).

Glyceride Analysis

The positional distributions of the fatty acids within the glycerides were determined by a combination of enzyme hydrolysis, TLC, and GLC (2). Pancreatic lipase (EC 3.1.1.3, glycerol ester hydrolase) was used to effect the lipolysis of the fatty acids at the 1- and 3-positions. The mixture of 2-monoglycerides and acids from the 1- and 3-positions were separated by TLC and the fatty acid composition of the recovered 2-monoglyceride was determined by GLC.

Tocopherol Determination

The oils were saponified under N_2 with pyrogallol added as an antioxidant. Tocopherols were then partially freed of other unsaponifiables by TLC, converted to trimethylsilyl ethers, and analyzed by GLC (7). The internal standard 5,7-dimethyltocol (8) was added prior to saponification.

RESULTS AND DISCUSSION

Conjugation and Peroxide Value

The oils contained no detectable peroxide; amounts of conjugated unsaturation ranged from 0.18 to 1.09%.

Fatty Acids

The fatty acids in the oils (Table II) were principally 16:0, 18:1, and 18:2, with lower amounts of 18:0, and, in the soybean oils, 18:3. Except for the long chain fatty acids in peanut oil, which totaled 7.0% of total fatty acid methyl esters, other acids occurred in amounts of less than 1%. The processed soybean-cottonseed oil blends contained slightly higher amounts of 18:2 than did the processed soybean oil, but less than the unprocessed cold pressed soybean oil. The

cold pressed soybean oil was also higher in 18:3 than the processed soybean oils (7.6% vs. 2.0-2.7%), but was no less saturated, suggesting that these processed oils were selectively hydrogenated to the monoene. Two of the three corn oils were essentially the same in fatty acid composition and differed from the third only in having slightly less 18:2 and more 18:1 and 18:3. The two safflower oils were essentially identical in their fatty acid compositions. The fatty acid compositions of peanut oil and olive oil were as expected; the former contained small amounts of long chain saturates and 22:1, and the latter was high in 18:1 and low in polyunsaturates.

Apricot kernel oil is of interest since it is said to be the principal food oil in the Pakistan province of Hunza, where the people are noted for their longevity (9). Articles in the popular press have speculated on the influence of diet, and particularly on the influence of the food fats, in this regard. The oil was characterized by an unusually low saturate content (6.4%) and by a high polyunsaturates/saturates (P/S) ratio, exceeded only by that of safflower oil.

The P/S ratios in Table III were calculated by dividing the total polyunsaturates, regardless of structure, by the total saturates, regardless of chain length. Safflower oil had the highest P/S ratio (8.6, 8.7) followed by apricot kernel oil (5.3), and corn oil (4.3, 4.3, 4.5). The lowest P/S ratios were those of peanut oil (1.8) and olive oil (0.5). Ratios of 18:2 to the sum of 16:0 and 18:0, sometimes used instead of total P/total S, differed little from those in Table III, except for peanut oil, which had a ratio of 18:2/(16:0 + 18:0) of 2.6.

TABLE III

Ratios of Polyunsaturated to Saturated Fatty Acids (P/S)[a]

Brand[b]	P/S Ratios
Wesson SBO/CSO	3.0
Nu-Made SBO/CSO	2.9
Giant SBO	2.8
Crisco SBO	3.0
Kraft SBO	2.6
Hollywood SBO	4.0
Ann Page CO	4.3
Nu-Made CO	4.3
Mazola CO	4.5
Saffola SFO	8.7
Hollywood SFO	8.6
Planters PO	1.8
Progresso OO	0.5
Golden Harvest AKO	5.3

[a]Calculated as: $\frac{\text{Sum of all polyunsaturated acids}}{\text{Sum of all saturated acids}}$

[b]Soybean oil = SBO; Cottonseed oil = CSO; Corn oil = CO; Safflower oil = SFO; Peanut oil = PO; Olive oil = CO; Apricot kernel oil = AKO

Glyceride Structure

The fatty acids at the 2-position were principally 18:1 and 18;2, accompanied by only minor amounts of other acids (Table IV). This is in agreement with the general rule that in vegetable oils 18:2 is preferentially esterified at the 2-position and saturated acids at the 1- and 3-positions. The percentages of 18:2 at the 2-position were 3 to 23% higher than those found in the total fatty acids. With the exception of peanut and apricot kernel oils, the percentage of 18:1 at the 2-position equalled or exceeded that in the total.

Because of the amount of work required to determine fatty acid positional distribution in triglycerides, attempts have been made to relate positional distribution to the more easily determined total fatty acid composition. One of the more successful attempts was that of Evans et al. (10) who proposed the following rules governing the distribution of fatty acids in vegetable fats: (a) 16:0, 18:0 and acids with chain lengths greater than 18 are randomly distributed between positions 1 and 3; (b) 18:1 and 18:3 are randomly distributed in all three positions; and (c) all remaining positions are filled with 18:2. The distributions found by analysis are compared with hypothetical values calculated by the Evans' rules in Table V. The hypothetical calculated values for corn, safflower, peanut, and cold pressed soybean oil agreed within 4 mole % with the values found by analysis. The processed soybean-cottonseed and soybean oils agreed almost as well, but were characterized by consistently lower amounts of 18:2 and higher amounts of 18:1 at the 2-position than the amounts calculated by the Evans' rules. This discrepancy may be expected in hydrogenated oils. The Evans' rules assume that all 18:1 is randomly distributed, and that 18:2 is preferentially esterified at the 2-position. The 18:1 formed from 18:2 during hydrogenation has the distribution of the parent 18:2, rather than that of naturally-occurring 18:1. This circumstance results in an overestimation of 18:2 and an underestimation of 18:1. Neither olive oil nor apricot kernel oil conformed to the hypothetical distribution: olive oil contained 12 mole % less 18:2 and apricot kernel oil 14 mole %

TABLE IV

Composition of Fatty Acids at the 2-Position of the Triglycerides

Brand[a]	16:0	18:0	18:1*cis*	18:1*trans*	18:2	18:3
	Weight percent of total fatty acid methyl esters					
Wesson SBO/CSO	1.3	0.6	33.7	3.3	59.6	1.6
Nu-Made SBO/CSO	1.4	1.4	28.4	9.6	56.9	2.5
Giant SBO	0.6	0.5	29.3	15.1	52.2	2.4
Crisco SBO	0.4	0.7	35.2	16.2	45.6	2.1
Kraft SBO	0.3	0.8	41.3	10.5	46.5	1.0
Hollywood SBO	0.4	–	25.1	–	68.4	6.0
Ann Page CO	1.4	0.1	26.1	–	71.6	0.7
Nu-Made CO	0.9	–	28.7	–	70.0	0.4
Mazola CO	1.2	–	26.0	–	72.8	–
Saffola SFO	0.2	–	11.9	–	87.9	–
Hollywood SFO	0.2	–	11.7	–	88.1	–
Planters PO	1.0	–	43.6	–	55.4	–
Progresso OO	0.5	–	90.7	–	8.5	0.4
Golden Harvest AKO	0.6	–	46.4	–	53.9	–

[a]Soybean oil = SBO; Cottonseed oil = CSO; Corn oil = CO; Safflower oil = SFO; Peanut oil = PO; Olive oil = CO; Apricot kernel oil = AKO

TABLE V

Positional Distribution of the Fatty Acids (FA): Comparison of Experimental Results with Hypothetical Values

Brand[a]	FA	In Total TG	2-Position		1,3-position	
			Foun Found	Evans Hyp.	Found	Evans Hyp.
			Mole percent			
Wesson SBO/CSO	16:0	12	1	0	20	20
	18:0	4	1	0	6	6
	18:1	33	37	33	31	33
	18:2	46	60	64	40	37
	18:3	3	2	3	4	3
Nu-Made SBO/CSO	16:0	12	2	0	17	18
	18:0	5	1	0	7	7
	18:1	35	38	35	33	35
	18:2	44	57	62	38	36
	18:3	3	3	3	4	3
Giant SBO	16:0	11	1	0	16	17
	18:0	5	0	0	7	8
	18:1	41	44	41	39	41
	18:2	41	52	56	35	31
	18:3	3	2	3	3	3
Crisco SBO	16:0	10	0	0	14	15
	18:0	4	1	0	6	6
	18:1	47	51	47	45	47
	18:2	37	46	50	32	30
	18:3	3	2	3	3	3
Kraft SBO	16:0	11	0	0	16	16
	18:0	5	1	0	7	7
	18:1	46	52	46	43	46
	18:2	36	46	52	31	29
	18:3	2	1	2	3	2
Hollywood SBO	16:0	12	0	0	17	17
	18:0	4	0	0	6	6
	18:1	24	25	24	24	24
	18:2	52	69	68	45	45
	18:3	8	6	8	8	8
Ann Page CO	16:0	12	2	0	18	18
	18:0	2	0	0	3	3
	18:1	26	26	26	26	26
	18:2	58	72	73	51	51
	18:3	1	1	1	2	1
	>18	1	0	0	1	1
Nu-Made CO	16:0	12	1	0	18	19
	18:0	2	0	0	3	3
	18:1	26	29	26	25	26
	18:2	58	70	73	52	51
	18:3	,1	0	1	2	1
Mazola CO	16:0	12	1	0	18	19
	18:0	2	0	0	3	3
	18:1	25	26	25	24	25
	18:2	60	73	75	54	53
	18:2	1	0	1	1	1
Saffola SFO	16:0	7	0	0	10	10
	18:0	2	0	0	3	3
	18:1	12	12	12	11	12
	18:2	79	88	88	75	74
	18:3	0	0	0	0	0
Hollywood SFO	16:0	7	0	0	10	11
	18:0	2	0	0	4	4
	18:1	11	12	11	11	11
	18:2	79	88	89	75	75
	18:3	0	0	0	0	0
Planters PO	16:0	11	1	0	16	17
	18:0	2	0	0	4	4
	18:1	47	43	47	49	47
	18:2	33	56	53	22	23
	18:3	0	0	0	0	0
	>18	6	0	0	9	9
Progresso OO	16:0	11	1	0	17	17
	16:1	1	0	1	1	1
	18:0	3	0	0	5	5
	18:1	78	90	78	71	78
	18:2	6	9	21	5	0
	18:3	1	0	1	1	1
Golden Harvest AKO	16:0	6	1	0	8	8
	16:1	1	0	1	1	1
	18:0	1	0	0	2	2
	18:1	58	46	58	64	58
	18:2	33	54	40	23	30
	18:3	1	0	1	1	1

[a]Soybean oil = SBO; Cottonseed oil = CSO; Corn oil = CO; Safflower oil = SFO; Peanut oil = PO; Olive oil = OO; Apricot kernel oil = AKO

more 18:2 at the 2-position than would be expected by the Evans' hypothesis.

Altered Fatty Acid Composition

Only the five "Specially Processed" oils containing soybean oil had more than trace amounts of *trans* unsaturation, as shown by infrared, and only these five were subjected to further examination for their total *trans* monoene and diene contents (Table VI), positional isomers of the monoene fraction (Fig. 1), and the amounts of *trans* monoene at the 2-position (Table IV). Most of the *trans* monoene was present as 18:1 *trans,* which varied in amount from 4.8 to 10.9 wt % of the total fatty acid methyl esters; the *trans* diene (ct + tc) was only 0.8 to 4.0 wt %. No *trans-trans* diene was found. The ratios of the *trans* monoene at the 2-position to that in the total were: Wesson SBO/CSO, 0.5; Nu-Made SBO/CSO, 2.0; Giant SBO, 1.9; Crisco SBO, 1.5; and Kraft SBO, 1.1. This tendency for the 2-position to have more *trans* monoene than the total is to be expected, since 18:2, whose hydrogenation results in 18:1t formation, is higher at the 2-position than at the 1- + 3-positions in the original oil.

The positional isomers of the 18:1c fractions (Fig. 1) were principally Δ9, accompanied by small amounts of Δ10, Δ11, and Δ12; in three of the oils, Δ8; and, in two of the oils, Δ6. The favored isomers in the 18:1t fractions were Δ9, Δ10 and Δ11, with smaller amounts of Δ8 and Δ12.

Tocopherols

Only alpha, gamma, and delta tocopherols were found (Table VII). Alpha tocopherol, the form of greatest interest since it has the highest vitamin E activity, was found in all the oils. Safflower oil was the richest in this form; apricot kernel oil, the poorest.

The variations in tocopherol content within a given oil type might be due to natural variations in the original oils or to losses caused by handling, storage, or processing. Cold pressing may be considered less destructive than other

TABLE VI

Geometrical Isomers of Oils Containing Processed Soybean Oil

	Soybean-Cottonseed		Soybean		
	Wesson	Nu-Made	Giant	Crisco	Kraft
	Weight percent of total fatty acid methyl esters				
18:1c	26.8	30.7	33.0	36.3	36.5
18:1t	6.7	4.8	7.8	10.9	9.3
18:2ct + 18:2tc	2.5	0.8	0.7	1.2	4.0
18:2cc	44.2	43.3	40.1	35.5	32.6

TABLE VII

Tocopherol Composition and Alpha Tocopherol to Polyunsaturated Fatty Acid (PUFA) Ratios

Brand[a]	Tocopherols			Alpha-T PUFA
	alpha	gamma	delta	
	mg/100 g			mg/g
Wesson SBO/CSO	13	63	20	0.26
Nu-Made SBO/CSO	11	81	18	0.23
Giant SBO	10	80	22	0.23
Crisco SBO	14	102	37	0.36
Kraft SBO	5	42	11	0.13
Hollywood SBO	9	68	23	0.15
Ann Page CO	12	46	4	0.23
Nu-Made CO	22	66	5	0.38
Mazola CO	18	75	–	0.30
Saffola SFO	48	–	–	0.61
Hollywood SFO	60	–	–	0.75
Planters PO	21	15	–	0.63
Progresso OO	14	–	–	2.26
Golden Harvest AKO	1	17	2	0.03

[a]Soybean oil = SBO; Cottonseed oil = CSO; Corn oil = CO; Safflower oil = SFO; Peanut oil = PO; Olive oil = OO; Apricot kernel oil = AKO

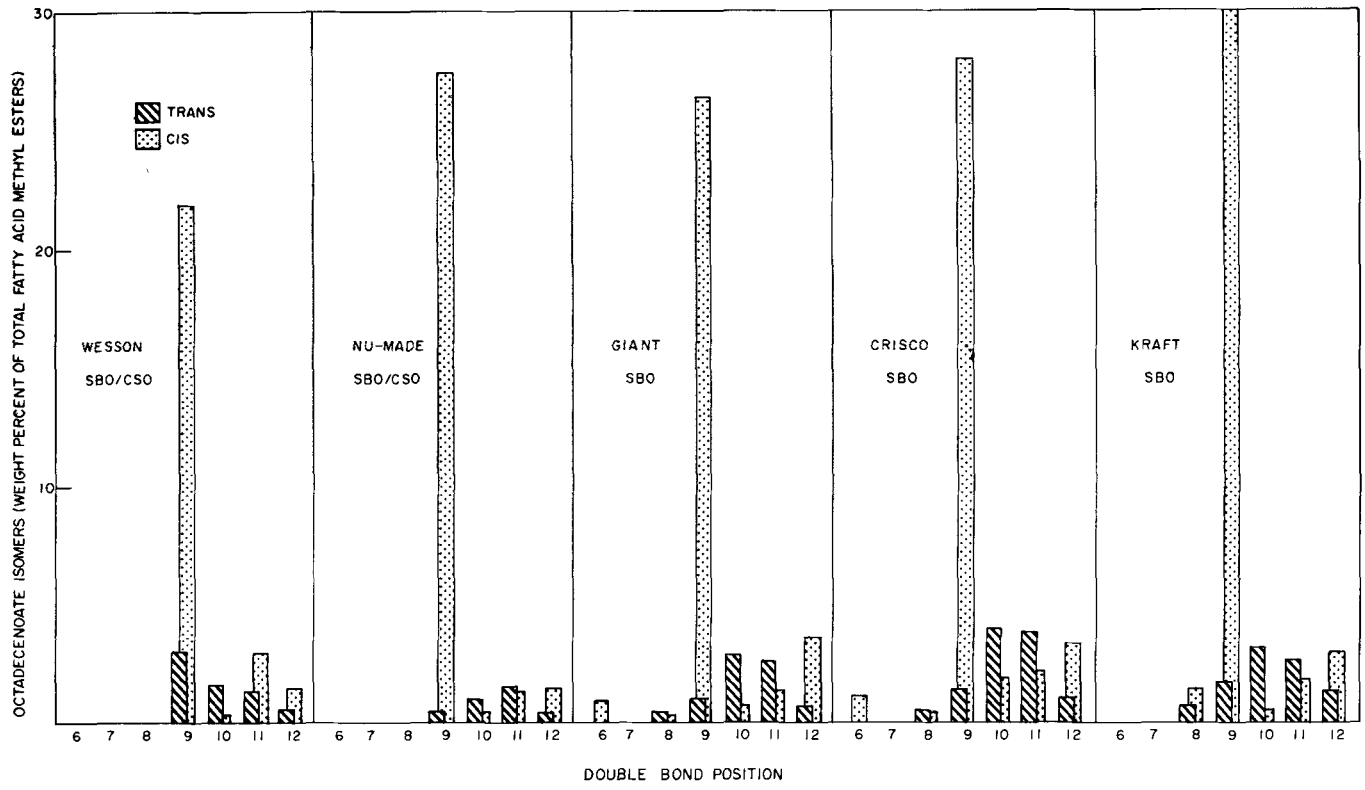


FIG. 1. Positional isomers in *cis*- and *trans*-octadecenoate fatty acids in salad oils containing processed soybean oil.

methods of oil extraction, and tocopherols might be expected to be higher in cold pressed oils. This was in fact true for safflower oil; the cold pressed oil contained 25% more alpha tocopherol than the non-cold pressed oil. On the other hand, the amounts of all three tocopherol forms in the cold-pressed soybean oil were exceeded by the amounts in one or more of the three processed soybean oils. These two observations suggest that the method of extraction may be less important than other factors in determining the vitamin E content of an oil.

The ratio of alpha tocopherol to polyunsaturated fatty acid has been suggested as a measure of the adequacy of dietary vitamin E (11). The recommendation has been made that a ratio of 0.6 mg of alpha tocopherol to 1g of polyunsaturated fatty acid be maintained (11). Since vegetable oils are major dietary sources of both vitamin E and polyunsaturated fatty acids, this ratio for the various oils (Table VII) is of interest. Of the 14 oils, only safflower, peanut, and olive oil had the recommended ratio of 0.6 or higher. The soybean-cottenseed, soybean and corn oils, which constitute the bulk of the oils consumed in the United States, all had ratios much lower than 0.6. Apricot kernel oil was lowest with a ratio of 0.03. On the basis of these data, it would be difficult to maintain the recommended intake of vitamin E on a highly unsaturated diet based on the more commonly used oils unless other foods rich in alpha tocopherol were included. Most dietary alpha tocopherol, however, comes from vegetable oils. A ratio of 0.6 seems unrealistically high, and it has recently been suggested that some lower ratio, possibly 0.2, may be adequate (12). At this lower level, most of these oils contain enough alpha tocopherol to balance their polyunsaturates. Only the apricot kernel oil and two of the soybean oils had ratios below 0.2.

The research conducted by the Agricultural Research Service, USDA, on the commercial vegetable oils as reported in this manuscript has been limited to analyses of their lipid composition. The data are reported solely as factual information and are limited to the samples analysed. No warranty or guarantee is made or implied that other samples of these products will have the same or similar composition. It is the policy of the USDA not to endorse those commercial products used in research over those which were not included in the research.

REFERENCES

1. Friend, B., National Food Situation 146:23 (1973).
2. Carpenter, D.L., and H.T. Slover, JAOCS 50:372 (1973).
3. Morrison, W.R., and L.M. Smith, J. Lipid Res. 5:600 (1964).
4. Morris, L.J., Ibid. 7:717 (1966).
5. Hill, E.E., D.R. Husbands, and W.E.M. Lands, J. Biol. Chem. 243:4440 (1968).
6. "Official and Tentative Methods of the American Oil Chemists' Society," 2nd edition, AOCS, Champaign, IL, 1964.
7. Slover, H.T., J. Lehmann, and R.J. Valis, JAOCS 46:417 (1969).
8. Lehmann, J., and H.T. Slover, Lipids 6:35 (1971).
9. Leaf, A., Nutrition Today 8:4 (1973).
10. Evans, C.D., D.G. McConnell, G.R. List, and C.R. Scholfield, JAOCS 46:421 (1969).
11. Harris, P.L., and N.E. Embree, Am. J. Clin. Nutr. 13:385 (1963).
12. Bieri, J.G., and R.P. Evarts, J. Am. Dietet. Assoc. 62:147 (1973).

[Received April 17, 1975]