Fruit Oils of Four Plant Species of Turkish Origin

A.T. Erciyes*, F. Karaosmanoglu and **H. Civelekoglu**
Faculty of Chemistry-Metallurgy, Istanbul Technical University, Maslak, Istanbul, Turkey

The characteristics of fatty oils recovered from seeds of four plant species of Turkish origin have been investigated. Seed oils of *Rhus coriaria* L. and *Ecballium elaterium* (L.) A. Rich. showed a close resemblance to those of previously published reports. Oil extracted from the seed of *Celtis australis* L. and *Gundelia tournefortii* L. show characteristics similar to fruit oils of the plant families to which they belong. In the focus of their technological evaluation, *Ecballium elaterium* seed oil can be regarded as a typical drying oil, while the others show characteristics of semidrying oils.

Resources of industrial raw materials are being increasingly consumed, and there is a growing interest for evaluating new oil-bearing seeds for both edible and technical purposes. In this report, the seed oil contents of species of plants belonging to four different botanical families which are indigenous in Turkey have been investigated. These species are designated in botanical systematics as follows: 1) *Rhus coriaria* L. (Fam.: Anacardiaceae); 2) *Ecballium elaterium* (L.) A. Rich. (Fam.: Cucurbitaceae); 3) *Celtis australis* L. (Fam.: Ulmaceae); and 4) *Gundelia tournefortii* L. (Fam.: Compositae).

MATERIALS

Oil-Bearing Fruits. Some botanical characteristics and origins of the four species are:

Rhus coriaria L., designated in common language as Sicilian Sumac or Sumach, is a shrub of 0.5-3 m height which grows wild in many regions of Turkey (1). The fruit is a globose, villous, and reddish colored drupe of 4-5 mm in diameter (Fig. 1). For this report the drupes were obtained from the township of Zile, located in a neighborhood of Kayseri (central Anatolia). The pericarp of the drupes are separated from the kernels without damage by passing the slightly crushed fruits through a suitable sieve. The pericarps liberated from the kernels are used as a valuable, sour-tasting, condiment in various locations in Anatolia. The kernels are the oil-bearing parts of the drupes. There have been only limited publications concerning the oil content of these kernels (2,3,4). The dried leaves of this shrub have been used as a tanning agent in leather-making since olden times (5).

Ecballium elaterium (L.) A. Rich., designated in common language as the Squirting Cucumber, is a perennial herb which grows wild on waste places, roadsides, river banks, etc. It is found mainly in the western Black Sea, the Marmara Sea, and the Aegean and Mediterranean regions of Turkey (6). *Ecballium elaterium* is a member of the plant family Cucurbitaceae. Its fruit is a pendulous fleshy capsule, 3-5 × 1.5-2.5 cm in size, which, at maturity, comes away from the peduncle and forcibly expels numerous seeds with a watery fluid through the aperture. The seeds are ovate, obscurely margined, and about 4 mm in size (Fig. 2). The mature seeds are the oil-bearing part of the fruit. The fleshy pulp of the capsules is exceedingly bitter. The fruit contains elaterin, which might have value as drasticum and diureticum. Publications concerning the oil characteristics of the seeds are rather limited (7,8,9). Mature seeds used for this report were collected with a closely knitted collecting basket in the surroundings of the village Darica, which is located in the vicinity of the township of Gebze (Kocaeli).

Celtis australis L., designated in common language as Nettle Tree or Southern Hackberry, is a member of the elm family (Ulmaceae). It is a tree of 20-25 m in height, found mainly in the Black Sea and the Aegean and Mediterranean regions of Turkey (10). The tree grows on open, rocky slopes, and in thickets. Rarely found in forests, it is usually solitary, and often planted. The fruits, which mature in late summer, are globulous, edible drupes of 9-12 mm in diameter and of brownish to blackish color (Fig. 3). The mature fruits investigated for this report were collected by hand from solitary trees in the surroundings of Goksu, a suburb on the Anatolian coast of the Bosphorus (Istanbul). The thin, fleshy mesocarp of the drupe is a sweet tasting pulp, and the endocarp is a rather bony stone. This stone contains a single kernel, which is the oil-bearing part of the fruit. Fats recovered from these drupes were used as burning oils in olden times (11). A previous report on the oil content of the fruit has already been published by Jones and Earle (12).

Gundelia tournefortii L. is a thistle-like, stout, perennial herb with milky latex that reaches a height of 20-100 cm. It grows wild, mainly in the central, eastern, south-eastern and Mediterranean regions of Anatolia. It thrives on rocky limestone, igneous slopes, steppes, near salt lakes, in open woodlands, and on fallow fields (13). The plant is a member of the Compositae family. The fruit, which matures in the late summer, is an achene enclosed in a woody capitulum of obovoid to tetragonal shape (Fig. 4). The capitula are 10-16 × 5-9 mm each, and several of them are aggregated into a secondary head (pseudocephalium) about 2-5 × 2-4 cm in size. The subject of this report is the oil-bearing achenes extracted from the woody capitula, which were collected in vicinity of Elazig (Eastern Anatolia) during the summer of 1983. Each capitulum contains just a single fertile achene, and its nearly flat, ovate-shaped kernel is approximately 3 × 6 × 7 mm in size. The species is collected and dried during the summer, and the crop is stored for winter fodder. Chewing-gum is prepared locally from the latex, and the capitula are also used as a coffee substitute after roasting (13). Characteristics of the oil content of the achene have already been reported by Barclay and Earle (14).

METHODS AND RESULTS

Fatty oil and moisture contents. Fatty oil contents of the oleaginous fruits were determined by solvent ex-

*To whom correspondence should be addressed.

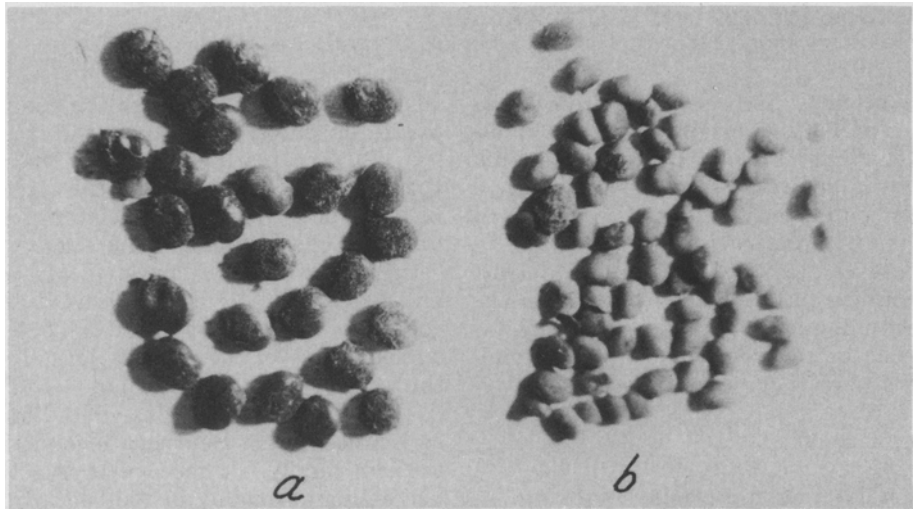

FIG. 1. *Rhus coriaria* L.: view of a) Drupes; b) Oil bearing kernels.

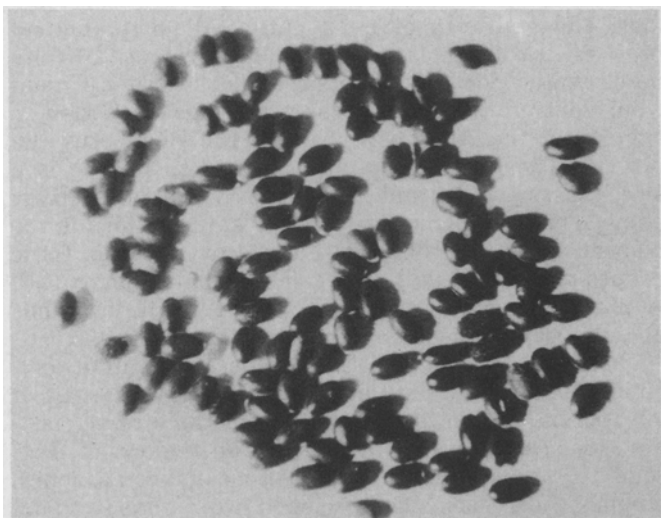

FIG. 2. Seeds of *Ecballium elaterium* (L.) A. Rich.

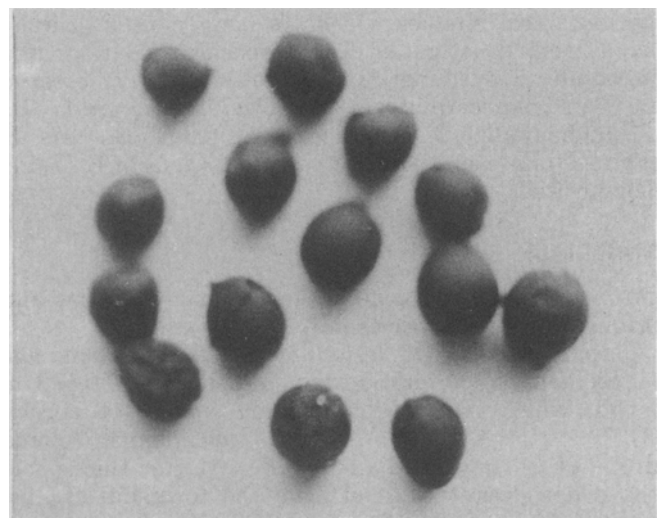

FIG. 3. *Celtis australis* L.: view of mature drupes.

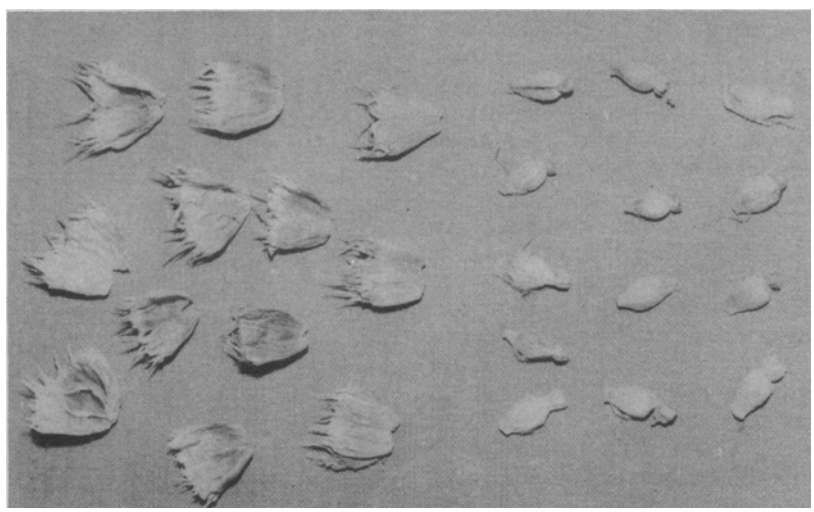

FIG. 4. *Gundelia tournefortii* L.: view of a) The dissected capitula; b) Achenes extracted from the capitula.

traction in a standard Soxhlet apparatus with freshly distilled petroleum ether (b.p. 40–60°C) as solvent (15). The moisture contents were determined by drying the crushed samples in a constant-temperature oven to constant weight at 105°C (16). Prior to both of the cited determinations, the samples were milled to such a size that 90% of them would pass through a sieve of 1 mm aperture (15). The results are shown in Table 1, which also includes some additional characteristics of the fruit samples and data quoted from a private communication of F.R. Earle, Northern Regional Research Center, Peoria, IL.

Oil constants and component fatty acid compositions. Characteristic constants of the oil samples were determined according to known standard methods (17–29). The results are recorded in Table 2. For the determination of component fatty acid compositions, the corresponding mixture of fatty acid methyl esters were prepared by refluxing the oil samples in a solution of BF_3 in methanol (30). The resulting products were subjected to analysis in a gas chromatograph model 2100 of Varian Aerograph Co., equipped with a flame ionization detector and a column with a stationary phase of 10% DEGS on chromosorb G (100/120 mesh) packing (31). Injection and column temperatures were adjusted to 240°C and 200°C, respectively. The flow rates for N_2, H_2, and air feeds were set to 45 ml/min. Evaluations of the corresponding chromatograms are represented in Table 3. In the case of *Ecballium elaterium* seed oil, the broad peak of the chromatogram representing the fraction of punicic acid (Fig. 5) could not be evaluated quantitatively (32). Therefore, the conjugated fatty acid content of the oil was determined by ultraviolet absorption analysis in a Beckman U.V. Spectrophotometer Model DB-GT (33). The absorptivity, $E_1{}^{1\%}_{cm}$, of the oil sample dissolved in cyclohexane was found to be 336.1 at 275 nm. Because the constant ($E_1{}^{1\%}_{cm}$) for pure punicic acid is 1694, as given in the literature (34), the punicic acid content of the oil was estimated to be 19.8%. Taking this result into considera-

TABLE 1

Technological Characteristics of Oil-Bearing Fruit Species (Unless Otherwise Stated Air Dry Basis)

	Results based on the present report	Data quoted from a private communication of F.R. Earle
Rhus coriaria:		
Average weight of 100 drupes, g	3	-
Average weight of 100 kernels, g	2	7–13.7 (g/1000)
Moisture content of kernels, %	6.2	5.3–6.5
Oil content of kernels (dry basis), %	16.0	0.2–9.2
Ecballium elaterium:		
Weight of 10 almost mature fresh capsules, g	65–75	-
Average number of seeds in 10 capsules	325–335	-
Average weight of 100 seeds, g	1.3	5.4–14.4 (g/1000)
Moisture content of seeds, %	10	4.0–7.3
Oil content of seeds (dry basis), %	31	32.7–57.6
Celtis australis:		
Average weight of 100 drupes, g	52	-
Average weight of 100 stones, g	18	174–270 (g/1000)
Average weight of 100 kernels, g	4.5	-
Moisture content of kernels, %	3.75	2.9–7.7
Oil content of kernels (dry basis), %	48	18–58
Gundelia tournefortii:		
Average weight of 100 capitula, g	20–25	-
Average weight of 100 achenes, g	3.5–6.24	39.4–65.7 (g/1000)
Moisture content of capitula, %	10	-
Moisture content of achenes, %	5.49	5.3–6.1
Oil content of capitula, %	11.35	-
Oil content of achenes (dry basis), %	39.17	35.3–39.3

TABLE 2

Some Characteristics of Oil Samples Originating From the Seeds of Four Different Plant Species (Values in Brackets are Quoted From A Private Communication of F.R. Earle, Northern Regional Research Center, Peoria, IL)

	Ecballium elaterium	*Rhus coriaria*	*Celtis australis*	*Gundelia tournefortii*	Method of test
Refractive index, n_D^{20}	1.4898	1.4750	1.4770	1.4730[a]	Ref. 17
	(1.4801)	—	(1.4683)	(1.4673)	—
Slip point, °C	15	12.8	11	17	Ref. 18
Sp. Gr., 20/20°C	0.9316	0.9211	0.9214	0.9273	Ref. 19
Viscosity, cP (20°C)	91.60	46.67	53.25	58.0	Ref. 20
Saponification value	189.6	189.9	190.1	193.7	Ref. 21
Acid value	3.9	0.95	1.36	1.26	Ref. 22
Unsaponifiable, %	0.135	1.255	0.945	0.125	Ref. 23
Rhodan value	83.66	79.56	81.43	77.7	Ref. 24
Reichert-Meissl value	0.285	0.40	0.60	0.2	Ref. 25
Polenske value	2.65	11.75	7.45	6.7	Ref. 26
Iodine value:					
Hanus	—	128.6	148.4	122.3	Ref. 27
	(136.0-132.6)	—	(140.8-141.1)	(122.0-122.7)	—
Kaufmann	137.2	127.5	145.9	126.8	Ref. 28
Woburn	159	—	—	—	Ref. 29
Hexabromide value, %	(3.2-4.5)	(0.4-0.8)	(0.2-1.0)	(1.9-2.3)	—

[a]At 25°C.

TABLE 3

Component Fatty Acid Composition of the Oil Samples (Values in Brackets are Quoted From a Private Communication of F.R. Earle, Northern Regional Research Center, Peoria, IL).

	Fatty acid composition, Wt.% of total				
Plant species	Palmitic	Stearic	Oleic	Linoleic	Punicic
Rhus coriaria	9.89	5.21	28.65	56.25	—
Ecballium elaterium	7.41	6.12	17.89	48.73	19.84
	(8.2-8.4)	(4.1-6.8)	(16.4-17.2)	(46.3-47.9)	(20.3-21.6)
Celtis australis	6.77	5.08	13.54	74.6	—
	(6.0)	(3.0)	(18.2)	(72.8)	—
Gundelia tournefortii	12.08	2.45	23.43	62.04	—
	(8.4)	(2.6)	(27.6)	(57.5)	—

tion, the percentage of the remaining component acids were calculated through evaluation of the above mentioned GL chromatogram (Fig. 5). These results can be found in Table 3.

Drying oil characteristics of Ecballium elaterium seed: oil gelation test. In accordance with ASTM Method D 1955 (gel time of drying oils) (35), 5 ml of *Ecballium elaterium* seed oil, and for comparison, 5 ml of a high-quality tung oil were subjected to a heat test at 288°C in order to determine their respective gel times. The time elapsed for the gelation of the tung oil sample was only 11 minutes, 30 seconds, whereas gelation of the *Ecballium elaterium* seed oil sample first occured after 10 hours and 45 minutes.

Drying time of untreated oil. The drying properties of *Ecballium elaterium* seed oil were mainly determined according to ASTM Method D 1953-70 (36). The tests were conducted by using oil samples both with and without driers. For comparison, the same tests were also conducted with sunflower and linseed oil samples under the same conditions. The results are given in Table 4.

DISCUSSION

Oil extracted from the seeds of four plant species, each belonging to a different family, have been investigated by emphasizing their technological evaluation. There are already some publications concerning the seed oil of *Rhus coriaria* (2,3,4), *Ecballium elaterium* (7,8,9), *Celtis australis* (12) and *Gundelia tournefortii* (14), and although the locations of collection are probably different, our results are close to those published in the previous reports. *Celtis australis* is a near relative of the species *Celtis occidentalis* L. (Hackberry). The seed oil of the latter has also been previously investigated (12,38) and, as expected, there is a certain resemblance in the composition and analytical values of the corresponding oils. *Gundelia tournefortii* is a member of the very large Compositae family, and its seed oil shows characteristics that are common to the oils found in most of the species of this family. The oil is rich in linoleic acid and contains less oleic acid and minor proportions of saturated acids. From the technological point of view, oils of *Rhus coriaria, Celtis australis,*

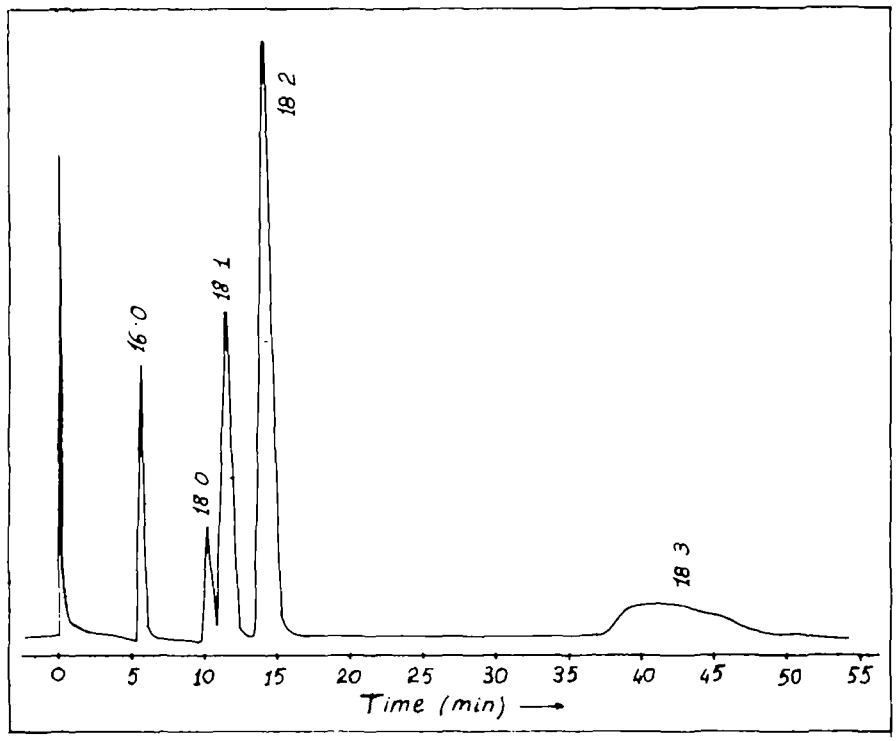

FIG. 5. Gas chromatogram of the methyl esters of *Ecballium elaterium* seed oil on DEGS packed column.

TABLE 4

Drying Times (Set-to-Touch) of *Ecballium elaterium* Seed Oil Sample, Compared with Sunflower and Linseed Oil Specimens

Condition of drying	Naphthenate dryer contents	*Ecballium elaterium* seed oil	Refined sunflower oil	Refined linseed oil
Exposed to diffused daylight[a]	None	144 hrs.	144 hrs.	112 hrs.
	0.5% Pb + 0.03% Co	70 mins.	370 mins.	225 mins.
	0.8% Pb + 0.08% Co[c]	40 mins.	300 mins.	—
Exposed to direct daylight[b]	None	30 hrs.	78 hrs.	42 hrs.
	0.5% Pb + 0.03% Co	65 mins.	330 mins.	210 mins.
	0.8% Pb + 0.08% Co[c]	35 mins.	290 mins.	—

[a]At 25°C and 55% relative humidity.
[b]At 35°C and 65% relative humidity.
[c]Ref. 37.

and *Gundelia tournefortii* can each be considered typical semidrying oils, whereas the seed oil of *Ecballium elaterium*, as can be seen from Table 4, is a typical drying oil. It gives a very clear and high-gloss film coating, which is probably due to the presence of punicic acid.

ACKNOWLEDGMENT

The authors thank the Haci Sakir Soap and Glycerol Manufacturing Company in Istanbul, who lent them a gas chromatograph.

REFERENCES

1. Davis, P.H., (Ed.), *Flora of Turkey and East Aegean Islands*, Edinburgh, 1967, Vol. 2, pp. 543-544.
2. Bravo, G.A., *Ann. Chim. Applicata 24*:427-30 (1934).
3. Al-Hamdany, R. and E. Osman, *J. Iraqi Chem. Soc. 2(1)*:87-93 (1977).
4. Barclay, A.S. and F.R. Earle, *Econ. Bot. 28(2)*:213 (1974).
5. Foerst, W., (Ed.), *Ullmanns Enzyklopaedie der Technischen Chemie, Urban und Schwarzenberg, Muenchen und Berlin*, 1960, Vol. 11, p. 588.
6. Davis, P.H., (Ed.), *Flora of Turkey and East Aegean Islands*, Edinburgh, 1972, Vol. 4, p. 203.
7. Chisholm, M.J. and C.Y. Hopkins, *Can. J. Chem. 42*:560-564 (1964).
8. Erciyes, A.T. and H. Civelekoglu, *Bull. Tech. Univ. Istanbul 36*:381-396 (1983).
9. Barclay, A.S. and F.R. Earle, *Econ. Bot. 38(2)*:230 (1974).
10. Davis, P.H., (Ed.), *Flora of Turkey and East Aegean Islands*, Edinburgh, 1982, Vol. 7, p. 650.
11. Augè, C., *Larousse Universel*, 1923, p. 247.
12. Jones, Q. and F.R. Earle, *Econ. Bot. 20(2)*:133 (1966).

13. Davis, P.H., (Ed.), *Flora of Turkey and East Aegean Islands*, 1975, Vol. 5, pp. 325-326, and 359.
14. Barclay, A.S. and F.R. Earle, *Econ. Bot. 28(2)*:233 (1974).
15. Snell, F.D. and L.S. Ettre, (Eds.), *Encyclopedia of Industrial Chemical Analysis*, 1971, Vol. 12, pp. 491-492.
16. Cocks, L.V. and C. van Rede, *Laboratory Handbook for Oil and Fat Analysts*, 1966, p. 17.
17. Cocks, L.V. and C. van Rede, *Ibid.*, pp. 99-101.
18. Cocks, L.V. and C. van Rede, *Ibid.*, pp. 88-90.
19. Cocks, L.V. and C. van Rede, *Ibid.*, pp. 80-88.
20. Cocks, L.V. and C. van Rede, *Ibid.*, pp. 102-103.
21. Cocks, L.V. and C. van Rede, *Ibid.*, pp. 117-120.
22. Cocks, L.V. and C. van Rede, *Ibid.*, pp. 113-117.
23. Cocks, L.V. and C. van Rede, *Ibid.*, pp. 123-126.
24. Kaufmann, H.P., *Analyse der Fette u. Fettprodukte*, Berlin, 1958, Vol. 1, pp. 591-592.
25. Cocks, L.V. and C. van Rede, *Laboratory Handbook for Oil and Fat Analysts*, pp. 164-168.
26. Cocks, L.V. and C. van Rede, *Ibid.*, p. 168.
27. Kaufmann, H.P., *Analyse der Fette u. Fettprodukte*, p. 571.
28. Kaufmann, H.P., *Ibid.*, pp. 571-572.
29. Kaufmann, H.P., *Ibid.*, pp. 581-582.
30. *1975 Annual Book of ASTM Standards*, Part 29, D 2800-69, pp. 360-361.
31. *Ibid.*, D 1983-69, pp. 264-269.
32. Chisholm, M.J. and C.Y. Hopkins, *Can. J. Chem. 42*:560 and 561.
33. Mattiello, J.J., (Ed.), *Protective and Decorative Coatings*, 1944, Vol. 4, pp. 362-405.
34. Hopkins, C.Y. and M.J. Chisholm, *J. Amer. Oil Chem. Soc. 45*:179 (1968).
35. *1975 Annual Book of ASTM Standards, Part 29, D 1955-61, pp. 230-231.*
36. *1975 Annual Book of ASTM Standards*, D 1953-70, p. 227.
37. Anonymous, Soligen Trockenstoffe, Chemische Fabrik Griesheim, Griesheim, 1951, pp. 71-72.
38. Yanovsky, E., E.K. Nelson and R.M. Kingsbury, *Science, 75*:565 (1932); Schuette, H.A. and R.G. Zehnpfennig, *Oil and Soap, 14*:269 (1937).

[Received September 12, 1988; accepted April, 27, 1989]
[J5565]