XLI. SEED FATS OF THE UMBELLIFERAE.

II. THE SEED FATS OF SOME CULTIVATED SPECIES.

BY BRIAN CROSSLEY CHRISTIAN
AND THOMAS PERCY HILDITCH.

From the Department of Industrial Chemistry, University of Liverpool.

(Received March 27th, 1929.)

ATTENTION has been directed in earlier communications [Hilditch and Jones, 1928; Hilditch, 1928] to the presence of $\Delta^{6:7}$ -octadecenoic acid or petroselinic acid in the fatty oil of parsley and other seeds of the Umbelliferae. It was shown in the preceding paper of this series that the seed fats of two native wild species of the order, *Heracleum Sphondylium* and *Angelica sylvestris*, contain in each case about 20 % of this isomeric oleic acid, together with 44–50 % of oleic, 25–33 % linoleic and about 4 % of palmitic acid. Seven other instances of Umbellate seed fats, drawn from common cultivated varieties, have now been examined and petroselinic acid has been found to be present in considerable amount in each case, the proportion varying from 26–60 % of the total mixed fatty acids.

It is therefore possible to state with some confidence that $\Delta^{6:7}$ -octadecenoic acid is characteristic of seed fats of the Umbelliferae. The presence of this acid has not been reported, moreover, in fats originating from any other botanical order with the sole exception of the Araliaceae (a closely allied Umbellate family). (It may be mentioned that, since our former communications, a further analysis of the seed fat of *Hedera Helix* has been published by Steger and van Loon [1928], who state that in this case 55 % of the mixed fatty acids consists of petroselinic acid.)

In the present work we have followed our usual procedure as far as possible, in order to obtain a quantitative measure of the various fatty acids present. The mixed fatty acids from the saponified fats were treated with lead acetate in alcoholic solution and a preliminary separation was thus effected into (1) saturated acids, petroselinic acid, and probably a little ordinary oleic acid, and (2) oleic and linoleic acids, possibly accompanied by traces of palmitic and petroselinic acids. The separation of ordinary oleic acid from petroselinic acid by this method is not likely to be completely quantitative, and therefore to that extent the results of the work must be considered of an approximate nature. The separation is, however, sufficiently marked to permit a reasonably accurate estimate of the content of petroselinic acid in the various fats to be obtained.

Each group of acids was then converted into methyl esters and the latter submitted to fractional distillation at a very low pressure.

Another complication, from the point of view of quantitative work, was the presence of non-fatty matter (frequently of a resinous character) in many of the ester fractions; this rendered the interpretation of the saponification equivalents of the latter doubtful in many cases. The same difficulty was encountered in the investigation of *Heracleum* and *Angelica* fats [Hilditch and Jones, 1928], and our experience confirms that of other workers who have noted that Umbelliferous seed fats are prone to be accompanied by unusually large amounts of non-fatty material both in the form of essential oils and of resinous compounds.

Although as much volatile essential oil as possible was removed by heating each fat in a vacuum prior to its hydrolysis, one or two instances were met with (notably, the seed fats of fennel and carrot) in which there remained some volatile compound of an unsaponifiable nature which eventually came over in the more volatile fractions of the distilled methyl esters.

Again, the saponification equivalents of the main ester fractions from certain of the fats (notably celery and parsnip) were sometimes erratic, apparently owing to small proportions of resinous (? lactonic) compounds which tended to distil along with the methyl esters.

The residues from the methyl ester distillations of course contained comparatively large amounts of non-volatile unsaponifiable matter, which, especially by reason of its dark colour, made the determination of mean saponification equivalents of these fractions extremely difficult.

Qualitative examination of the fatty acids present in the methyl ester fractions obtained indicated in all cases that the acids present were only palmitic, petroselinic, oleic and linoleic¹; no saturated acid lower than palmitic was detected, and the hexabromide test failed to disclose the presence of any linolenic acid in any of the specimens examined. Consequently the numerical calculations have been based wherever possible on the observed iodine values rather than the equivalents, except that in those fractions containing large amounts of unsaponifiable matter (that is, the residual non-volatile fractions and certain of the lowest boiling fractions in the cases of fennel, carrot and caraway) the proportion of unsaponifiable matter has been determined from the saponification equivalent figures.

EXPERIMENTAL.

The seed fats investigated were extracted by means of carbon tetrachloride from the ground dried seeds. We are much indebted to Mr T. E. Miln, of Messrs Gartons Ltd., who very kindly procured for us supplies of the various

¹ The methods employed in these investigations have not disclosed up to the present the occurrence of a diethylenic acid structurally related to $\Delta^{6,7}$ -octadecenoic acid rather than to $\Delta^{9,10}$ -octadecenoic acid; but the possibility of the existence of such an acid should not be overlooked.

seeds and ensured that the material handled was of definite botanical origin. The crude seed fats obtained by the solvent extraction (in amounts varying from 350–950 g.) had the characteristics shown in the following table.

Table I.

Species	Common name	Fat content of seed %	Saponification equivalent	Acidity (as % oleic acid)	I. V.	Characteristics of seed fat	
						Unsaponifiable matter	
						Non-volatile	Volatile (up to 150°/1 mm.)
<i>Foeniculum capillaceum</i> Gilib.	Fennel	13.3	309.4	16.9	87.9	11.3	5.0
<i>Daucus Carota</i> Linn.	Carrot	15.9	307.7	8.0	106.4	13.25	0.9
<i>Coriandrum sativum</i> Linn.	Coriander	8.8	289.6	28.6	89.5	9.27	1.1
<i>Apium graveolens</i> Linn.	Celery	14.4	291.8	5.7	129.1	2.9	15.2
<i>Pastinaca sativa</i> Linn.	Parsnip	17.3	272.1	12.9	92.7	2.6	—
<i>Chaerophyllum sativum</i> Gartn.	Chervil	11.3	295.3	1.7	139.4	3.3	—
<i>Carum Carvi</i> Linn.	Caraway	9.0	300.9	9.9	112.1	0.9	13.9

The volatile essential oils removed by vacuum treatment of the heated crude fats were not further investigated, since they had no bearing on the immediate purpose of the research. The non-volatile unsaponifiable matter was not removed from the fatty acids prior to further treatment, but was left to accumulate in the residues from the ester distillations.

The crude seed fats (after removal of volatile matter as described) were saponified with excess of alcoholic potash, and the mixed crude fatty acids isolated and dried.

The fatty acids (1 part) were dissolved in boiling 95 % alcohol (5 parts) and mixed with a boiling solution of lead acetate (0.7 part) in 95 % alcohol (5 parts). After boiling for a few minutes the mixture was set aside overnight at room temperature and the separated lead salts were removed by filtration next morning. The insoluble lead salts were recrystallised from a volume of 95 % alcohol equal to that employed in the original separation, and separated by filtration after standing at room temperature overnight. The recrystallised insoluble lead salts were converted back to the fatty acids, and are referred to below as "solid" acids. The mother liquors from the recrystallisation were (except in the case of parsnip seed fat) united with the original alcoholic filtrates, and the recovered acids therefrom are denoted as "liquid" acids. In the case of the parsnip fatty acids the "liquid" acids from the two alcoholic filtrates were worked up separately.

The yields of the two groups of acids from the various seed fats are shown in Table II.

Each group of fatty acids obtained (1 part) was separately dissolved in methyl alcohol (2 parts) and heated under reflux in presence of 2 or 3 % of sulphuric acid for 2 hours; this effected almost quantitative conversion into

the corresponding methyl esters which, after removal of most of the excess of methyl alcohol, were taken up in ether and washed with dilute sodium carbonate solution until neutral. The crude neutral methyl esters were heated in a vacuum at about 100° to remove the last traces of solvent and were then fractionally distilled.

Table II.

	"Solid" acids		"Liquid" acids	
	%	I.V.	%	I.V.
Seed fat				
Fennel	60.2	83.1	39.8	110.2
Carrot	57.1	87.0	42.9	145.5
Coriander	59.6	79.8	40.4	104.7
Celery	54.0	84.8	46.0	119.5
Parsnip	46.2	87.6	21.7	128.2
			32.1	119.0
Chervil	57.5	100.7	42.5	175.7
Caraway	28.7	80.2	71.3	127.5

The results of the methyl ester separations are summed up in the next series of tables, together with the calculated composition of the individual fractions, determined in the majority of cases (as already stated) from the iodine values in conjunction with the data obtained by qualitative examination of individual ester fractions.

For those fractions which contained notable amounts of unsaponifiable matter it was essential to utilise in addition the saponification equivalents: in these instances the soap solutions from the saponified esters were thoroughly extracted with ether, and the saponification equivalent and iodine value of the recovered fatty acids (freed from unsaponifiable matter) were then determined. These values calculated back to the corresponding methyl esters are (when necessary) inserted in the tables between brackets.

For purposes of identification, individual ester fractions were hydrolysed and the resulting soaps oxidised by means of dilute ice-cold alkaline permanganate solution according to the directions of Lapworth and Mottram [1925]. The liberated mixture of dihydroxy- and tetrahydroxy-stearic acids was boiled with light petroleum (B.P. 40–50°) to effect the removal of any saturated fatty acids; the latter (only palmitic acid was detected) were purified by crystallisation from aqueous alcohol. The crude hydroxystearic acids were boiled with water in order to remove any sativic acid and then crystallised from ethyl acetate.

Petroselinic acid was readily identified in the form of the corresponding 6:7-dihydroxystearic acid, which melts at 121–122°. The 9:10-dihydroxy-acid from ordinary oleic acid, which melts at 130°, was used to define the presence of $\Delta^{9:10}$ -oleic acid. In all cases the identity of the compounds was checked by determination of mixed melting point with authentic specimens of the respective acids.

In several cases a dihydroxystearic acid (or quite possibly an equilibrium mixture of acids) was encountered which melted consistently at 113–115°.

This substance was only met in oxidation products from the "liquid" esters and it is possible that it indicates the presence, in the acids with soluble lead salts, of a certain amount of petroselinic acid; alternatively, it must be borne in mind that there is some possibility that a linoleic acid corresponding with petroselinic acid may be present in fats of this type. If such an acid exists, the means at present employed in the isolation of petroselinic acid are insufficient to lead to its separation.

We may now proceed to tabulate the analytical data which we have obtained for the seven seed fats investigated.

Table III. *Fennel*.*Methyl esters of "solid" acids.*

No.	g.	B.P./1 mm.	Sap. equiv.	I.V.	Estimated composition		
					Palmi- tate	Petro- selinate	Unsaponi- fiable
S 1	6.5	129/144°	284.8	68.9	1.3	5.2	—
S 2	25.8	144/147	294.5	72.9	3.9	21.9	—
S 3	75.9	147/153	298.3	84.5	—	75.9	—
S 4	7.6	Residue	441.7 (345.7)	89.7	—	5.1	2.5
115.8					5.2	108.1	2.5
					% as esters	93.4	2.2
					% as acids	93.3	2.3

Methyl esters of "liquid" acids.

					Palmi- tate	Oleate	Lin- oleate	Unsap.
L 1	6.5	80/142°	343.7 (279.5)	71.7	1.4	2.3	1.6	1.2
L 2	5.0	142/145	300.7 (283.7)	102.8	0.5	2.5	1.7	0.3
L 3	43.8	145/147	294.2	120.5	—	26.3	17.5	—
L 4	16.1	Residue	560.6 (345.9)	97.8	—	5.2	3.3	7.6
71.4					1.9	36.3	24.1	9.1
					% as esters	50.9	33.7	12.8
					% as acids	50.6	33.5	13.3

Fraction	Fatty acids identified
S 1	Palmitic, M.P. 60–61° (ca. 20 % of fraction); 6 : 7-dihydroxystearic, M.P. 121°
S 3	6 : 7-Dihydroxystearic, M.P. 120–121°, and a trace of saturated acid
L 3	Dihydroxystearic mixture (?), M.P. 113–115°

Estimated composition of mixed fatty acids.

	"Solid" %	"Liquid" %	Total	Percentage (excluding unsaponifiable)
Palmitic	60.2	39.8	3.7	4
Petroselinic	2.6	1.1	56.2	60
Oleic	56.2	—	20.1	22
Linoleic	—	20.1	13.3	14
Unsaponifiable	—	13.3	6.7	—

Table IV. *Carrot.**Methyl esters of "solid" acids.*

No.	g.	B.P./1 mm.	Sap. equiv.	I.V.	Estimated composition		
					Palmi- tate	Petro- selinate	Un- saponi- fiable
S 1	5.4	69/138°	291.5	73.2	0.8	4.6	—
S 2	33.1	138/149	293.9	81.6	1.6	31.5	—
S 3	12.4	149/152	295.4	84.6	0.1	12.3	—
S 4	34.1	152/153	296.4	86.0	—	34.1	—
S 5	11.5	Residue	326.1	80.0	—	10.4	1.1
96.5					2.5	92.9	1.1
% as esters					2.7	96.2	1.1
% as acids					2.7	96.2	1.1

Methyl esters of "liquid" acids.

					Palmi- tate	Oleate	Lin- oleate	Unsap.
L 1	7.1	118/149°	624.3 (282.0)	154.9 (93.1)	1.1	0.7	1.4	3.9
L 2	6.9	149/154	330.9 (298.4)	123.1 (103.6)	1.7	1.6	2.9	0.7
L 3	10.5	154/156	303.8	138.2	—	4.2	6.3	—
L 4	28.8	156/160	298.8	141.9	—	10.2	18.6	—
L 5	13.5	Residue	373.1	91.4	—	3.8	6.9	2.8
66.8					2.8	20.5	36.1	7.4
% as esters					4.1	30.8	54.1	11.0
% as acids					4.1	30.6	53.8	11.5

Fraction	Fatty acids identified
S 1	Palmitic, M.P. 63.5° (ca. 20 % of fraction); 6 : 7-dihydroxystearic, M.P. 120–121°
S 4	6 : 7-Dihydroxystearic, M.P. 121–121.5°
L 4	Dihydroxystearic mixture (?), M.P. 113–115°

Estimated composition of mixed fatty acids.

	"Solid" %	"Liquid" %	Total	Percentage (excluding unsaponifiable)
Palmitic	57.1	42.9	3.3	4
Petroselinic	1.5	1.8	54.9	58
Oleic	—	13.1	13.1	14
Linoleic	—	23.1	23.1	24
Unsaponifiable	0.7	4.9	5.6	—

Table V. *Coriander.**Methyl esters of "solid" acids.*

No.	g.	B.P./1 mm.	Sap. equiv.	I.V.	Estimated composition		
					Palmi- tate	Petro- selinate	Unsaponi- fiable
S 1	8.3	110/147°	278.8	54.0	3.1	5.2	—
S 2	7.7	147/152	283.3	61.4	2.2	5.5	—
S 3	81.6	145/146	291.0	79.2	6.2	75.4	—
S 4	15.6	Residue	571.6	78.5	—	8.1	7.5
113.2					11.5	94.2	7.5
% as esters					10.2	83.2	6.6
% as acids					10.1	83.0	6.9

Table VI (*cont.*)*Estimated composition of mixed fatty acids.*

	"Solid" %	"Liquid" %	Total	Percentage (excluding unsaponifiable)
	54.0	46.0		
Palmitic	2.6	0.6	3.2	3
Petroselinic	50.1	—	50.1	51
Oleic	—	25.3	25.3	26
Linoleic	0.7	18.5	19.2	20
Unsaponifiable	0.6	1.6	2.2	—

Table VII. *Parsnip.**Methyl esters of "solid" acids.*

No.	g.	B.P./1 mm.	Sap. equiv.	I.V.	Estimated composition		
					Palmi- tate	Petro- selinate	Unsaponi- fiable
S 1	5.9	158/160°	281.1	79.9	0.4	5.5	—
S 2	18.5	160/161	285.0	85.5	—	18.5	—
S 3	4.4	Residue	350.0	79.4	—	4.1	0.3
	28.8				0.4	28.1	0.3
				% as esters	1.4	97.5	1.1
				% as acids	1.4	97.5	1.1

Methyl esters of "liquid" acids L 1

(from first crystallisation of lead salts).

					Oleate	Linoleate	Unsaponi- fiable
L 1/1	3.1	119/157°	291.4	130.6	1.5	1.6	—
L 1/2	4.6	157/159	294.5	127.6	2.4	2.2	—
L 1/3	4.8	Residue	300.5	111.2	2.2	2.0	0.6
	12.5				6.1	5.8	0.6
				% as esters	48.5	46.5	5.0
				% as acids	48.4	46.4	5.2

Methyl esters of "liquid" acids L 2

(from recrystallisation of lead salts).

					Palmitate	Oleate	Linoleate
L 2/1	4.0	108/154°	289.8	109.2	0.2	2.5	1.3
L 2/2	11.2	154/155	297.2	116.0	—	7.3	3.9
L 2/3	4.4	Residue	299.4	110.3	—	3.2	1.2
	19.6				0.2	13.0	6.4
				% as esters	1.2	66.0	32.8
				% as acids	1.2	66.0	32.8

Fraction

Fatty acids identified

S 2 6 : 7-Dihydroxystearic, M.P. 122°, with trace saturated acid

L 1/2 9 : 10-Dihydroxystearic, M.P. 129–130°

L 2/2 Dihydroxystearic mixture (?), M.P. 113–114°

Estimated composition of mixed fatty acids.

	"Solid" %	"Liquid"		Total	Percentage (excluding unsaponifiable)
		L 1 %	L 2 %		
	46.2	21.7	32.1		
Palmitic	0.7	—	0.4	1.1	1
Petroselinic	45.0	—	—	45.0	46
Oleic	—	10.5	21.2	31.7	32
Linoleic	—	10.1	10.5	20.6	21
Unsaponifiable	0.5	1.1	—	1.6	—

Table VIII. *Chervil*.*Methyl esters of "solid" acids.*

No.	g.	B.P./1 mm.	Sap. equiv.	I.V.	Estimated composition			
					Palmi- tate	Petro- selinate	Lin- oleate	Unsaponi- fiable
S 1	3.4	90/141°	282.5	91.3	0.5	2.2	0.7	—
S 2	42.1	141/145	283.6	93.6	4.8	28.8	8.5	—
S 3	10.1	145/149	290.5	105.7	—	7.8	2.3	—
S 4	7.3	Residue	313.6	110.3	—	5.3	1.6	0.4
62.9					5.3	44.1	13.1	0.4
					% as esters	8.4	70.1	20.8
					% as acids	8.4	70.1	20.8
								0.7

Methyl esters of "liquid" acids.

No.	g.	B.P./1 mm.	Sap. equiv.	I.V.	Palmi- tate	Oleate	Lin- oleate	Unsap.
L 1	5.7	115/154°	285.9	153.5	0.6	0.1	5.0	—
L 2	68.3	154/155	298.5	172.3	—	0.4	67.9	—
L 3	3.8	155/157	297.7	170.5	—	0.1	3.7	—
L 4	10.4	Residue	292.4	135.7	—	0.2	8.1	2.1
88.2					0.6	0.8	84.7	2.1
					% as esters	0.7	0.8	96.1
					% as acids	0.7	0.8	95.9
								2.6

Fraction

Fatty acids identified

S 1	Palmitic, M.P. 57–59°; 6 : 7-dihydroxystearic, M.P. 120–121°
S 2	Palmitic, M.P. 60–61°; 6 : 7-dihydroxystearic, M.P. 121–122°
L 2	Dihydroxystearic mixture (?), M.P. 113–114°, tetrahydroxystearic, M.P. 169–170°, with traces of saturated acid (M.P. 50–52°) and water-soluble tetrahydroxy-stearic acid (M.P. 150°)

No linolenic acid was present (absence of insoluble hexabromides)

Estimated composition of mixed fatty acids.

	"Solid"	"Liquid"	Total	Percentage (excluding unsaponifiable)
	%	%		
	57.5	42.5		
Palmitic	4.8	0.3	5.1	5
Petroselinic	40.3	—	40.3	41
Oleic	—	0.3	0.3	0.5
Linoleic	12.0	40.8	52.8	53.5
Unsaponifiable	0.4	1.1	1.5	—

Table IX. *Caraway*.*Methyl esters of "solid" acids.*

No.	g.	B.P./1 mm.	Sap. equiv.	I.V.	Estimated composition		
					Palmi- tate	Petro- selinate	Un- saponi- fiable
S 1	12.5	123/130°	287.2	66.7	2.8	9.7	—
S 2	13.6	130/132	289.0	79.8	0.9	12.7	—
S 3	14.5	132/133	296.1	84.9	0.2	14.3	—
S 4	4.7	Residue	397.1 (355.6)	64.2 (63.9)	—	3.5	1.2
45.3					3.9	40.2	1.2
					% as esters	8.6	88.7
					% as acids	8.6	88.6
							2.8

Table IX (cont.)

Methyl esters of "liquid" acids.

					Estimated composition			
					Palmitate	Oleate	Linoleate	Unsap.
L 1	3.9	100/142°	310.7 (293.9)	114.6 (114.0)	0.3	1.9	1.5	0.2
L 2	18.9	142/144	295.9	112.0	—	13.2	5.7	—
L 3	49.3	144/146	298.2	123.7	—	27.9	21.4	—
L 4	23.7	146/148	296.0	129.4	—	11.8	11.9	—
L 5	13.8	148/149	295.9	127.3	—	7.2	6.6	—
L 6	15.6	Residue	469.3 (336.1)	122.1 (77.3)	—	5.1	4.7	5.8
125.2					0.3	67.1	51.8	6.0
					% as esters	0.2	53.6	41.4
					% as acids	0.2	53.5	41.3
Fraction					Fatty acids identified			
S 1	Palmitic, M.P. 61–62°; 6 : 7-dihydroxystearic, M.P. 121–122°							
S 3	6 : 7-Dihydroxystearic, M.P. 120–121°							
L 4	Mixture of dihydroxystearic acids							

Estimated composition of mixed fatty acids.

	"Solid"	"Liquid"		Percentage (excluding unsaponifiable)
	%	%	Total	
	28.7	71.3		
Palmitic	2.5	0.1	2.6	3
Petroselinic	25.4	—	25.4	26
Oleic	—	38.2	38.2	40
Linoleic	—	29.4	29.4	31
Unsaponifiable	0.8	3.6	4.4	—

DISCUSSION OF RESULTS.

Inspection of the above tables shows that, whilst the quantitative interpretation of the results cannot reach the order of accuracy obtainable by the fractionation method in the absence of volatile resinous and unsaponifiable matter, the latter is concentrated for the most part in the methyl esters of those acids, the lead salts of which were soluble in alcohol. The analyses of the methyl esters derived from the insoluble lead salts are comparatively straightforward, and qualitative tests led to the ready identification of petroselinic acid, in the form of the characteristic 6 : 7-dihydroxystearic acid, and of palmitic acid. Consequently the figures quoted for the percentages of petroselinic acid are quite definite, and provide the necessary data for the main object of the investigation.

It is convenient to summarise the final results for the composition of the mixed fatty acids of each of the seven seed fats at this point.

Table X. *Percentage composition of fatty acids.*

	Palmitic	Petroselinic	Oleic	Linoleic
Fennel	4	60	22	14
Carrot	4	58	14	24
Coriander	8	53	32	7
Celery	3	51	26	20
Parsnip	1	46	32	21
Chervil	5	41	0.5	53.5
Caraway	3	26	40	31

Quite evidently, petroselinic acid occurs in abundance in each of the seed fats now examined. The proportion in each case varies, however, somewhat widely, and whilst, on the one hand, the lowest figure (26 % in the case of caraway seed fat) is higher than that in *Heracleum* or *Angelica* (20 % [Hilditch and Jones, 1928]), the highest values now recorded (58 % in carrot seed fat and 60 % in fennel seed fat) are much lower than the corresponding value for parsley fat (76 % [Hilditch and Jones, 1927]). It is, of course, impossible to make any speculations as to the cause of the varying proportions of the acid in different genera, or even to suggest why Umbelliferae and some related orders of plants should elaborate an isomeric form in addition to the usual oleic acid. The variability in composition may, however, be contrasted with the case of the Palmae, in which genera so diverse as *Cocos nucifera*, *Elaeis guineensis* and *Attalea Cohune* contain not only the same mixture of fatty acids but (within 2 or 3 %) the same proportions of the predominating components, lauric, myristic and palmitic acids [Hilditch, 1928].

An attempt was made in the case of fennel, carrot and caraway seeds to determine whether the composition of the endosperm fat differed materially from that of the fatty oil present in the vittae. The dried seeds were ground up and then exposed to a current of air in such a way that the lighter fragments of the mericarp structure were displaced and the heavier particles collected. The results, however, were quite inconclusive, for on separating the fatty acids obtained from the fat in the concentrated heavy material by the lead salt method, the data observed were as follows:

Table XI.

	Fennel	Carrot	Caraway
<i>Whole seed:</i>			
% Fatty oil	13	16	9
"Solid" fatty acids: % of total acids	60	57	29
Iodine value	83.1	87.0	80.2
<i>Separated seed:</i>			
Percentage of whole seed	74	84	93
% Fatty oil	21	15	15
"Solid" fatty acids: % of total acids	63	47	19
Iodine value	81.2	82.5	71.9

So far as can be judged from this experiment, therefore, the variation in percentage of petroselinic acid does not seem to be connected with varying proportions of vittae fat and true seed fat in the different seeds.

The amount of palmitic acid, the only saturated acid present in these seed fats, is comparatively small and constant, the average figure being in the neighbourhood of 3-4 % of the total fatty acids.

Oleic and linoleic acids, which make up the remainder of the total fatty acids, are not present in constant relative proportions; but in the cases of the seed fats of fennel, carrot, celery, parsnip, and caraway the amount of oleic acid present is from 40-60 % of the combined oleic and linoleic acids, and in several cases the proportions are of much the same order.

The oleic and linoleic acid contents of chervil seed fat stand apart from the rest, since this portion of the chervil fatty acids was found to consist almost exclusively of linoleic acid; the tetrahydroxystearic acid of melting-point 169–170° was obtained in quantity from this acid, which therefore would appear to consist largely of the usual $\Delta^{9:10,12:13}$ -linoleic acid.

The low linoleic acid content of coriander seed fat may well be due to accidental circumstances, the seed in this case having deteriorated somewhat during storage; and therefore we do not attach too much significance to this particular figure.

SUMMARY.

Seven further seed fats from cultivated species of the order Umbelliferae have been examined, and it has been found that $\Delta^{6:7}$ -octadecenoic (petroselinic) acid is present in quantity in all cases. The view that the presence of this acid is characteristic of Umbellate seed fats is thus strengthened.

The other components of the mixed fatty acids are palmitic acid in small quantity (1–8 %), together with $\Delta^{9:10}$ -octadecenoic (ordinary oleic) acid and linoleic acid in somewhat varying proportions.

The fatty oils are accompanied in all cases by considerable amounts of unsaponifiable and resinous matter, which renders the quantitative investigation somewhat less certain than in other cases in which it has been applied.

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