Fatty Acid Composition of *Cuphea* Seed Oils

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ABSTRACT

Nineteen species of 10 taxonomic sections of *Cuphea* were analyzed for fatty acid composition of the seed oils. Two sections of the genus, *Trispermum* and *Pseudocircaea,* previously unreported, are included. Lauric acid is the major component of the seed oil in seven of the species surveyed; capric and myristic each predominate in five. Linolenic acid, previously thought to be only a trace component of *Cuphea* seed oils, is the major constituent of two species. Two others are rich in linoleic acid, another minor component of most *Cuphea* oils.

INTRODUCTION

Most plants whose seed oils have been analyzed for fatty acid composition are rich in long-chain ($>C_{16}$) fatty acids; those which have a majority of short- or medium-chain acids are relatively rare. Lauric acid predominates in species of the Lauraceae and Palmae families, and several Ulmaceae are rich in capric (1); few other groups of this type are known. Some *Cuphea* (family Lythraceae) species are known to be rich in caprylic, capric, lauric or myristic acids (2-6), and correlations have been made between the major fatty acids, when considered in conjunction with floral morphology, pollen studies and chromosome number, and the phylogenetic relationships of the species (2). These medium-chain fatty acids are important to the chemical industry for manufacture of detergents, surfactants, lubricants and other products; currently, they are derived from imported coconut or palm kernel oil. *Cuphea* appears to be a potential source of medium-chain acids which can augment or replace these imports. It is hoped that a domestic species suitable as a crop may be developed through breeding programs which utilize these primarily South and Central American *Cuphea.* Mutation experiments have already met with some success in removing morphological characteristics that are disadvantageous to agricultural use (5,7).

The fatty acid compositions of oils of 19 new species, in 10 taxonomic sections are reported in an effort to identify diversity in the *Cuphea* germplasm collection.

EXPERIMENTAL PROCEDURES

Seeds were collected in the wild from New World plants (see Table I), and voucher specimens are available. Samples were small (2-50 seeds) due to limited availability. The seeds were ground in a 15 X 2 cm test tube in a Brinkmann Homogenizer in 2 mL of redistilled pentane and placed on a rotary shaker at medium speed for ca. 1 hr. The solvent was transferred by pipette to a 10-mL tapered-bottom flask and evaporated to dryness. The residue (oil) was then dissolved in 2 drops of benzene; 5 mL of 5% HCl in methanol was added, and the solution was refluxed for 1 hr. Resulting methyl esters were extracted from the mixture with pentane in a separatory funnel, and the pentane was evaporated off with a stream of N_2.

Contaminants from impure solvents were a problem; therefore, the esters were isolated on precoated thin layer chromatographic plates (Merck, silica gel 60, 0.25 mm thickness), with hexane/diethyl ether (85:15) as the developing solvent. Location of the esters on the plate was determined by visualization with dichlorofluorescein under ultraviolet light. Esters were recovered by extracting the silica scraped from the plate with pentane or ether.

The fatty acid methyl esters were analyzed by gas chromatography using a 25 m SP-1000 glass capillary column, 0.25 mm id (Packard Instrument Co., Downers Grove, IL), temperature programmed from 75 C to 210 C at 4 C/min. Detection was by flame ionization. Esters were identified by equivalent chain lengths with known saturated fatty acid methyl esters as standards (8).

RESULTS AND DISCUSSION

Fatty acid compositions of *Cuphea* seed oils are summarized in Table I. Five of the *Cuphea* species, in three sections, are rich in capric acid (10:0): Sect. *Brachyandra, C. ferrisiae;* Sect. *Heterodon, C. koehneana, C. viscosissima* and *C. quaternata;* Sect. *Leptocalyx, C. calaminthifolia.* The five species of Sect. *Brachyandra* previously reported, as well as *C. calophylla,* are high in lauric acid (12:0) (2); making the pattern of *C. ferrisiae* unique in this section. This species shows morphological and palynological affinities to both Sect. *Brachyandra* and Sect. *Heterodon* (9); the fatty acid composition suggests it may be more closely related to the latter. However, as is most evident in Sect. *Heterodon,* both in species presently and previously (2,5) reported, diversity in the major fatty acid among species of the same section is not unknown. Capric, lauric, linoleic (18:2) and linolenic (18:3) acids are all found as a major constituent of different species in Sect. *Heterodon.*

Seven of the species analyzed are rich in lauric acid: Sects. *Brachyandra, Heterodon, Leptocalyx, Melvilla* and *Pseudocircaea* (previously unreported) are represented by this group. *C. calophylla* contains the highest percentage of lauric acid (85.0%) of any *Cuphea* analyzed. Two accessions of *C. vesiculigera* differ markedly in their fatty acid composition: one collected in Jalisco, Mexico, is rich in myristic acid; the other, collected in Guerrero, Mexico, has a preponderance of lauric acid. Thus the premise that in *Cuphea* the main fatty acid component is stable over the geographical range of the species (2) may need to be reevaluated as additional samples become available.

Myristic acid (14:0) is the major constituent of *C. epilobiifolia* (Sect. *Heteranthus*), two subspecies of *C. strigulosa* (Sect. *Euandra*), one accession of *C. vesiculigera* previously mentioned (Sect. *Heterodon*) and of *C. sessilifolia* (Sect. *Trispermum*). Sects. *Heteranthus* and *Euandra* were formerly known for high lauric (2); Sect. *Trispermum* was previously unreported.

Linoleic acid (18:2) is probably the seed oil constituent found in greatest proportions in the angiosperms; however, in the genus *Cuphea* it is the major component of only two species surveyed: *C. lindmaniana* (Sect. *Cuphea*) and *C.*

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TABLE I

Fatty Acid Composition of *Cuphea* Seed Oils

		Percent fatty acid										
Species	Origin	8:0	10:0	12:0	14:0	16:0	18:0	18:1	18:2	18:3	20:0	20:1
Sect. *Brachyandra*												
C. calophylla Cham. & Schlect.	Costa Rica	0.1	5.0	**85.0**	6.8	1.1	0.1	0.5	1.3	—	—	—
C. ferrisiae Bacig.	Mexico	1.2	**82.2**	1.9	1.0	3.2	tr[a]	2.7	4.4	6.4	—	—
	Mexico	0.7	—	0.8	**35.2**	12.0	2.7	20.0	22.5	—	—	—
C. vesiculigera RC Foster	Mexico	tr	0.4	**71.2**	18.0	2.6	0.2	2.4	5.0	—	0.1	0.1
Sect. *Cuphea*												
C. lindmaniana Bacig.	Brazil	0.1	0.5	0.6	0.6	17.3	1.6	18.2	**55.3**	—	4.1	1.7
Sect. *Diploptychia*												
C. spectabilis S. Graham	Mexico	0.6	0.2	1.2	2.7	15.1	1.2	26.0	22.2	**30.8**	—	—
Sect. *Euandra*												
C. strigulosa H.B.K. subsp. *nitens* Koehne	Brazil	0.9	18.1	13.8	**37.3**	10.3	1.3	7.3	11.0	—	—	—
C. strigulosa H.B.K. subsp. *opaca* Koehne	Peru	tr	tr	33.7	**45.2**	7.0	0.8	5.2	7.1	0.8	0.2	—
Sect. *Heteranthus*												
C. epilobiifolia Koehne	Panama	tr	0.3	31.8	**55.3**	5.2	0.8	1.2	4.9	0.1	0.1	0.2
Sect. *Heterodon*												
C. viscosa Rose	Mexico	0.2	0.3	**59.9**	31.4	2.1	0.2	1.9	4.0	—	—	—
C. trochilus S. Graham	Mexico	—	0.1	**61.8**	24.7	3.0	0.2	2.8	7.1	0.2	0.1	0.1
C. viscosissima Jacq.	USA	9.1	**75.5**	3.0	1.3	3.1	0.3	1.9	4.7	0.5	0.3	0.4
C. koehneana Rose	Mexico	0.1	**91.6**	1.5	0.6	1.3	0.3	1.1	3.1	0.2	0.1	0.1
C. quaternata Bacig.	Mexico	0.1	**62.9**	8.2	15.6	4.1	0.5	2.2	5.1	1.4	tr	—
C. flavovirens S. Graham	Mexico	tr	20.5	9.5	5.3	15.2	2.2	21.6	**22.9**	1.1	0.4	1.3
C. purpurascens Bacig.	Mexico	2.2	—	0.9	3.1	19.0	2.2	17.2	17.6	**36.1**	—	—
Sect. *Leptocalyz*												
C. calaminthifolia Schlect.	Mexico	tr	**43.7**	tr	4.1	13.0	1.5	12.5	25.2	—	—	—
C. infundibulum Koehne	Costa Rica	0.2	3.2	**82.7**	7.7	1.7	0.4	1.6	2.4	—	—	—
Sect. *Melvilla*												
C. jorullensis H.B.K.	Mexico	0.1	32.0	**53.1**	4.1	1.5	0.6	2.7	5.0	—	0.1	0.1
Sect. *Pseudocircaea*												
C. lutescens Koehne	Brazil	1.0	1.7	**65.5**	26.3	2.7	0.2	1.8	0.9	—	—	—
Sect. *Trispermum*												
C. sessilifolia Mart.	Brazil	1.1	—	10.2	**36.6**	19.1	9.9	23.1	—	—	—	—

[a]tr = Trace, <0.1%.

flavovirens (Sect. *Heterodon*). The four species of Sect. *Cuphea* reported by Graham et al. (2) were also rich in linoleic but none of Sect. *Heterodon* were. In *C. flavovirens*, capric acid is nearly as abundant as linoleic.

Linolenic acid (18:3) has been known to occur in only trace amounts in *Cuphea* seed oils. However, it is found in significant quantities in a number of the species surveyed here, and is the major fatty acid of two species, *C. purpurascens* (Sect. *Heterodon*) and *C. spectabilis* (Sect. *Diploptychia*). This is most remarkable in *Diploptychia*, since it is the only section that has been reported to show a preponderance of caprylic acid (8:0) (2,5). Linolenic and caprylic acids are widely divergent not only in chain length but also in evolutionary significance. According to Graham et al. (2), a positive correlation can be made between evolutionarily advanced morphological characters and oils rich in short-chain, saturated fatty acids such as capric and caprylic. This may indicate that *C. spectabilis* is closely related to species in other sections where longer-chain fatty acids can be predominant.

As more *Cuphea* seed becomes available, further work is desirable to confirm that the seeds collected for this study are a representative sample of the population, as well as to elucidate the variation in fatty acid composition within a species over a wide spectrum of ecological niches.

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