COUMARINS AND ESTERS OF *Ferula microcarpa*

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Continuing a study of the coumarins and esters of plants of the genus *Ferula*, we have investigated the neutral and phenolic components of the roots of *Ferula microcarpa* Eug. Korov. collected in the Kyzart pass.

By chromatographing the neutral fraction of a methanolic extract on a column of silica gel, in addition to the kamolol [1] and feropolol [2], known previously, we have isolated a new terpenoid coumarin, C_{24}H_{32}O_{4}, M^+ 384, which we have called fecarpin (I).

The UV spectrum of (I) [λ_max 220, 243, 290, 327 nm (log ε 4.14, 3.58, 3.78, 3.98, respectively)] is characteristic for umbelliferone derivatives. The IR spectrum shows absorption bands at 1615, 1570, and 1514 cm⁻¹ (aromatic nucleus), 1715 cm⁻¹ (C=O of an α-pyrone), and 3530 cm⁻¹ (OH), confirming that fecarpin is a coumarin derivative. The hydroxy group in fecarpin is secondary -- under mild conditions it is readily acetylated. A comparison of the PMR spectra of fecarpin and kamolol showed that they differ in their CS values and in the multiplicity of the signal of the hemihydroxylic proton (m, 3.58 ppm, δ_{1/2} = 9 Hz) and also by a slight change in the CSs of the signals of the methyl groups. These facts indicate that fecarpin is a stereoisomer of kamolol in relation to the orientation of the hydroxy group.

In fact, when (I) was oxidized with chromium trioxide in acetone, a compound with the composition C_{24}H_{30}O_{4}, M^+ 282, mp 190-192°C, was obtained which was identical according to its IR and PMR spectra with kamolone [1, 3].

Thus, the hydroxy group in fecarpin has the axial orientation and the configurations of the other asymmetric centers are the same as in kamolone [4].

On the basis of the facts given it may be concluded that fecarpin has the following structure and configuration:

![Structure of Fecarpin](image)

By chromatographing the phenolic fraction of the extract on a column of silica gel, we isolated two esters, which we have called microferin, C_{22}H_{38}O_{5} (II), M^+ 340, and microferinin, C_{23}H_{30}O_{4} (III), M^+ 370. Both compounds are readily soluble in alkalies, benzene, chloroform, ether, and ethanol, sparingly soluble in hexane, and insoluble in water.

The UV spectrum of (II) shows a maximum at 260 nm (log ε 4.22), and the UV spectrum of (III) has maxima at 266 nm (log ε 4.02) and 296 nm (log ε 3.23) due to the presence of the p-hydroxybenzoyl and 3,4-dihydroxybenzoyl chromophores, respectively. In the presence of alkali, the long-wave maxima undergo bathochromic shifts by 44 and 54 nm, respectively, which shows the phenolic nature of both compounds.

The IR spectra of microferin and microferinin contain, in addition to the absorption bands of an aromatic nucleus and of hydroxy groups, the carbonyl bands of esters of phenolic carboxylic acids (1670 and 1690 cm⁻¹, respectively).

On alkaline hydrolysis, (II) and (III) formed the same sesquiterpene alcohol -- microferol, C_{15}H_{24}O (IV), M^+ 220 -- and acids: in the case of microferin, p-hydroxybenzoic acid, and in the case of microferinin vanillic acid.
The PMR spectrum of the alcohol (IV) showed the following signals: broadened singlet at 5.29 ppm (1H, J/2 = 6.7 Hz, -CH=CH-), singlet at 1.59 ppm (6H, 2C = C--CH3), two doublets at 0.83 and 0.96 ppm (3H each, J = 7 Hz, -CH3), and a septet at 3.79 ppm (1H, J = 5.5, 9.0, 10.5 Hz, -CH--OH). When (IV) was acetylated with acetic anhydride in pyridine, a monoacetate C17H26O2 was obtained in the PMR spectrum of which the signal of the hemihydroxy group had undergone a paramagnetic shift by 1.08 ppm.

On the basis of the composition and chemical and spectral characteristics, we propose for the alcohol the bicyclic guaianane structure (IV), which was confirmed by the formation of gualazulene from (II) and (III) on dehydrogenation with selenium at 200-230°C.

The position of the hydroxy group at Cα in microferol is unambiguously determined by the nature of the splitting of the signal of the hemihydroxylic proton.

Thus, microferin and microferinin are esters of the guaiane alcohol microferol (IV) with p-hydroxybenzoic and vanilllic acids, respectively.

The orientations of the ester group and of the isopropyl radical in (II) and (III) follow from the SSCC of the signal of the hemiacetyl proton. In the spectra of (II) and (III) the latter appears in the form of a septet at 5.16 ppm with J = 5.5, 9.0, and 10.5 Hz, which shows the equatorial orientations [5] of the ester and isopropyl groups in microferin and microferinin. It must be mentioned that the microferinin that we isolated proved to be identical with a compound obtained previously by the cyclization of chimganidin in an acid medium [6]. On the basis of the fact given, for compounds (I) and (II) we propose the following structures and configuration:

\[ \text{II. } R=\text{OC--C}_{6}\text{H}_{5}--\text{OH} \]
\[ \text{III. } R=\text{OC--C}_{6}\text{H}_{5}(\text{OH})_{2} \text{(OCH}_{3} \text{)} \]
\[ \text{IV. } R=\text{H} \]

The purity of the substances and the course of the reactions were checked by the TLC method on Silufol in chloroform–ethyl acetate (4:1) (for coumarins) and (25:1) (for esters). The coumarins were detected in UV light and the esters were revealed with a 1% solution of vanillin in concentrated sulfuric acid and a 3% solution of potassium permanganate.

Isolation of the Coumarins. The dried and comminuted roots were extracted with ethanol (3 × 5 liters). The extract was concentrated, diluted with water (1:2), and extracted with ether (4 × 0.25 liter). The ethereal extract was treated with 1% caustic potash solution and was then washed with water and dried, and the solvent was distilled off. This gave 60 g of a resinous residue, 50 g of which was deposited on a column of KSK silica gel (3.5 × 110 cm). The coumarins were eluted (2:1) [sic], 100-ml fractions being collected.

EXPERIMENTAL