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STRUCTURE OF MUCROFLAVONE A

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A new flavonoid, mucroflavone A, is isolated from the terrestrial part of Tanacetopsis mucronata *(Regel. et Schmalh.) S. Kovalevsk. IR, mass, UV, and PMR spectra are compared with those of related compounds to provide a basis for proposing the structure 5,6,4′-trihydroxy-8,3′-dimethoxyflavone for mucroflavone A.*

We continued our study of the plant *Tanacetopsis mucronata* [1-5] by isolating a new flavonoid with mp 240°C and composition $C_{17}H_{14}O_7$ and naming it mucroflavone A (**1**). Mucroflavone A gives a positive qualitative reaction characteristic of flavonoids [6].

The IR spectrum of **1** contains absorption bands characteristic of hydroxyl (3490 cm^{-1}), carbonyl (1660 cm^{-1}), and an aromatic ring (1620 and 1580 cm^{-1}). The mass spectrum gives fragments split in two ways typical of flavonoids. These indicate the presence in ring *A* of two hydroxyl and one methoxy group and in ring *B* of one hydroxyl and one methoxy group [7, 8].

The PMR spectrum has a strong singlet at 12.8 ppm, which is characteristic of a hydroxyl proton on C-5 [7]. The UV spectrum in MeOH with added $AlCl_3$ confirms the presence of the hydroxyl owing to a bathochromic shift by 33 nm of the absorption band at 340 nm [9].

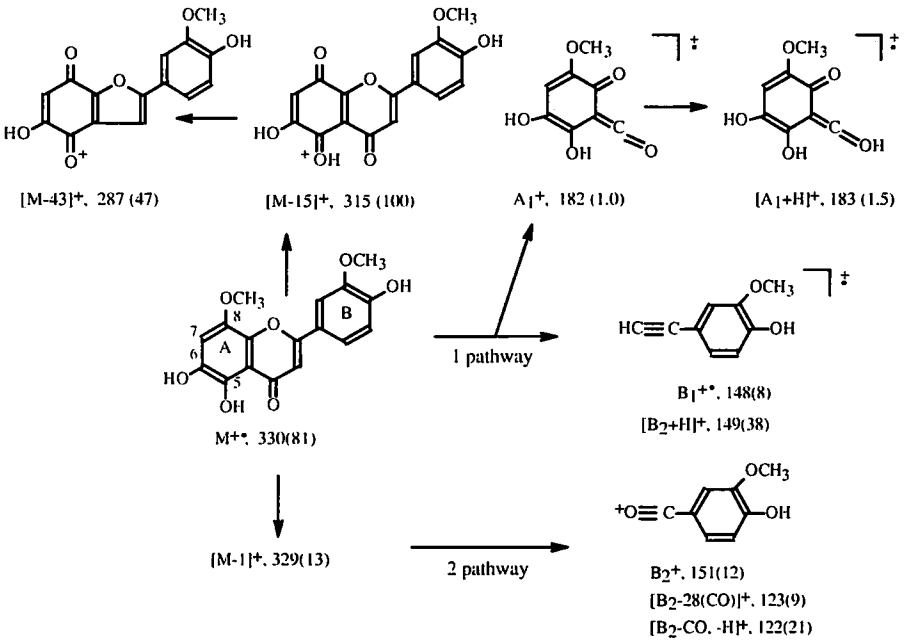

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TABLE 1. UV Spectra of Mucroflavone A and Similar Compounds

Compound	λ, nm					
	MeOH* EtOH**	+NaOAc	+NaOAc +H_3BO_3	+$AlCl_3$	+$AlCl_3$ +HCl	+MeONa* +EtONa**
1*	290***	254	254	256	254	249
	340***	380	343	373	365	330, 399
2**	284, 298	284		309		
[13]	343	352		436		
3**	256, 274	277	268	276		
[14]	351	393	376	302, 342		
				431		
4*	244, 253, 276	280	254, 276	262, 284	260, 284	273, 282
[15]	343	325, 410	340	300, 360	300, 352	340, 412
				402	397	
5*	281		232		287	269
[17]	305		307		320,347	321
					426	
6*	243, 277	237, 278		259, 290	238, 278	
[13]	340	322, 364		363	312, 376	

*Spectrum taken in MeOH. **Spectrum taken in EtOH. ***First line is absorption band II; second and third lines are absorption band I.

TABLE 2. PMR Spectra of Mucroflavone A (δ, ppm, J, Hz) and Related Compounds **2** [13], **4** [15], **5** [17], and **7** [18-20]

Compound	Protons									
	H-3	H-6	H-7	H-8	H-2'	H-3'	H-5'	H-6'	OMe	5-OH
1**	6.81s	-	6.82s	-	7.52d	-	7.17	7.55q	3.72s	12.8s
					J = 2.5		J = 9	J = 2.5,	3.84s	
								J = 9		
2***	6.68s	-	-	6.85s	7.43m	-	6.89d	7.43m	3.93s	12.66
							J = 9			
4*	6.5s	6.3s	-	-	7.5d	-	6.97d	7.55m	3.97s	
					J = 2.5		J = 9	J = 2.5		
			-	-				J = 9		
5***	6.56s	6.88s			8.15d	7.13d	7.13d	8.15d	3.87s	12.44s
					J = 8	J = 8	J = 8	J = 8	3.91s	
7***	6.86s			6.60s	7.5-7.6m	-	6.92d	7.5-7.6	3.88s	13.0s
							J = 9		3.75s	

*Spectrum taken in CCl_4. **Spectrum taken in Py-D_5. ***Spectrum taken in DMSO-D_6. (Signals designated by the same signs can be inverted).

Three structures are possible for **1** taking into account these facts and that fact that two hydroxyls and one methoxy group are set on ring *A* in the mass spectrum. The second hydroxyl can be located on C-6, C-7, or C-8. Although hydroxyls in dihydroxyflavonoids are often situated on C-5 and C-7 (i.e., 5,7-dihydroxyflavonoids are common), comparison of the UV and PMR spectra of **4**, **6**, and **7** with that of **1** (Tables 1 and 2) demonstrated that they are substantially different. The absorption band at 340 nm (band I) undergoes a bathochromic shift by 40 nm relative to λ_{max} in the spectrum recorded in MeOH and band

II remains unchanged in the UV spectrum of **1** recorded with added NaOAc. Thus, the effect that is observed in UV spectra of 5,7-dihydroxyflavonoids taken in MeOH with added NaOAc relative to λ_{max} in the spectrum taken in MeOH (i.e., bathochromic shifts of bands I and II by 5-20 and 5-35 nm, respectively) [6] does not occur. Absorption bands II in substances **4** and **6** are observed at 280 and 278 nm, respectively. The absorption band at 340 nm in the UV spectrum of **1** taken in MeOH with added NaOMe undergoes a bathochromic shift by 59 nm. However, the absorption band at 249 nm remains unchanged. This is observed for substance **4**. These facts argue against 5,7-dihydroxy groups.

Comparison of the UV and PMR spectra of **1** and **7** (5,8-dihydroxyflavone) also indicates that they are substantially different. On one hand, the $[M^+ - 15]$ base peak (100%) in the mass spectrum of **1** is consistent with the presence of a methoxy group and the lack of a hydroxyl on C-8 [7, 8]. Thus, the mass spectrum excludes not only the 5,8-dihydroxy grouping but also a methoxy group on C-7 in a 5,6-dihydroxyflavonoid. The absorption band at 365 nm (I) in the UV spectrum of **1** taken in MeOH with added $AlCl_3$ + HCl undergoes a bathochromic shift by 25 nm relative to λ_{max} observed in the spectrum taken in MeOH. This is consistent with a hydroxyl on C-6 [11].

An absorption band is observed at 343 nm (band I) in the UV spectrum of **1** taken in MeOH with added NaOAc + H_3BO_3. This suggests the lack of a detectable bathochromic shift ($\Delta\lambda_{max}$ = 3 nm) relative to λ_{max} observed in the spectrum recorded in MeOH. This is possible only if 5,6-dihydroxyls are present [7]. Furthermore, qualitative reaction for *p*-dihydroxyls gave a negative test whereas the result was positive for *o*-dihydroxyls [10].

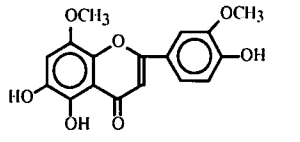
The UV spectra suggest that ring *A* contains 5,6-dihydroxy-8-methoxy substituents.

A bathochromic shift (band I) by 66 nm without an intensity change in the spectrum taken with added NaOMe indicates that a 4′-OH group is present [6, 10, 12].

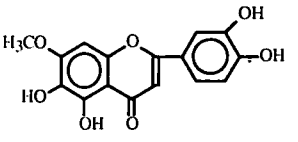
The PMR spectrum of **1** in C_5D_5N (see Table 2) contains signals for aromatic protons at 6.80 (in ring *A*), 7.17, 7.52, and 7.55 ppm; an olefinic proton at 6.82 (in ring *B*), protons of two methoxy groups at 3.78 and 3.87 ppm, and a C-5-OH hydroxy proton at 12.8 ppm. Protons H-2′ and H-6′ are symmetrically disposed relative to the C-2–C-1′ bond. They are approximately equally shielded. The signals for H-2′ and H-6′ appear at 7.52 and 7.55 ppm as a doublet ($^4J_{2',6'}$ = 2.5 Hz) and a quartet ($^4J_{2',6'}$ = 2.5 Hz, $J_{5',6'}$ = 9 Hz), respectively [18-20].

The chemical shifts and spin—spin coupling constants of the ring *B* protons indicate that they are situated on C-2′, C-5′, and C-6′. Protons H-5′ and H-6′ interact with an *ortho* constant whereas H-2′ and H-6′ are situated *meta* to each other. Comparison of these PMR spectra with those of compounds with 4′-OH and 3′-CH_3 substituents on ring *B* (**4** and **7**, see Table 2) confirms this. The signal at 6.82 ppm belongs to H-7.

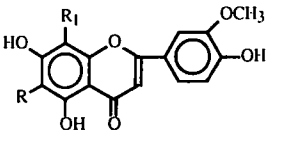
This signal occurs usually at lower field than that of H-3, which appears as a singlet at 6.81 ppm in the spectrum of **1**. The signal resonating as a doublet at 7.17 ppm ($^3J_{5',6'}$ = 9 Hz) belongs to H-5′. The signal for the methoxy protons on C-8 appears at 3.87 ppm whereas the methoxy protons on C-3′ resonate at 3.72 ppm. These data and a comparison of the UV and PMR spectra with compounds of similar structure (see Table 2) enable the structure 5,6,4′-trihydroxy-8,3′-dimethoxyflavone (**1**) to be proposed for mucroflavone.



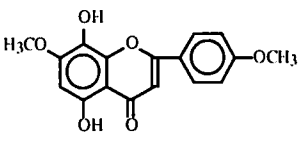
1



2



3: R=OH, R_1=H
4: R=H, R_1=OCH_3



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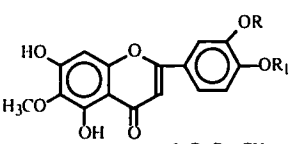

6: R=R_1=CH_3
7: R=CH_3, R_1=H

EXPERIMENTAL

IR spectra were recorded on a UR-20 (KBr) spectrophotometer; mass spectra, on an MX-1303 spectrometer; PMR, on a Tesla BS-567 A instrument at 100 MHz; UV spectra, on a Specord UV-Vis spectrophotometer. TLC was performed on Silufol UV-254 plates using benzene—alcohol (4:1), ethylacetate—hexane (3:2), and $CHCl_3$—acetone (17:3). The plates were developed by 1% vanillin in conc. H_2SO_4.

Isolation of mucroflavone A. Concentrated mother liquors (4.69 g) were rechromatographed on KSK silica gel at a 1:50 ratio [3]. Eluents were hexane (fraction 1), hexane—$CHCl_3$ (1:1, fraction 2), and $CHCl_3$ (fractions 3-70). The volume of the eluents was 100 ml. Recrystallization from fractions 13-36 gave a yellow finely crystalline substance with mp 240°C (acetone—hexane). R_f 0.74 (ethylacetate—hexane, 3:2), 0.53 (benzene—alcohol, 4:1), 0.26 ($CHCl_3$—acetone, 17:3).

IR spectrum, ν, cm^{-1} (KBr): 3490 (–OH), 2960 (CH_3, CH_2, CH), 1660 (C=O of α-pyrone), 1580-1620 (aromatic C=C bond), 1515, 1468, 1430, 1375, 1296, 1260, 1210, 1170, 1135, 1100, 1030.

Mass spectrum, *m/z* (%): 330 (M^+, $C_{17}H_{14}O_7$, 81), 329 (13.04), 317 (9), 316 (19.6), 315 (M^+ - 15, 100), 313 (19.6), 312 (M^+ - 18, 69.56), 310 (8.69), 302 (4.35), 301 (11), 300 (M^+ - 30, 10), 288 (11), 287 (47), 284 (12), 272 (5), 256 (6.52), 183 (1.5), 182 (A_1^+, $C_8H_6O_5$, 1), 167 (21.74), 165 (8.69), 153 (10.86), 151 (11.74), 149 (38), 148 (B_1^+, $C_9H_8O_2$, 8), 143 (10.86), 139 (B_2^+, $C_7H_7O_3$, 17.39), 136 (11.30), 134 (12.61), 129 (11), 125 (9.8), 123 (9), 122 (21), 119 (10.86), 109 (11.95), 105 (17.39), 99 (13.04), 98 (10.43), 97 (19.57), 96 (12.39), 95 (18.48), 93 (13.93), 91 (11.95), 89 (13.04), 85 (15.43), 84 (11.74), 83 (21.74), 82 (13.48), 81 (19.57), 77 (16.52), 73 (14.78), 71 (22.82), 70 (15.22), 69 (53.69), 68 (9.99), 67 (14.13), 60 (11.52), 57 (34.98), 56 (17.39), 55 (34.78), 44 (21.74).

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