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TEUCRINS H1–H4, NOVEL CLERODANE-TYPE DITERPENES FROM *TEUCRIUM HYRCANICUM*

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Key Word Index—*Teucrium hyrcanicum*; Labiatae; structural determination; stereochemistry; rearranged labdane, norclerodane-, clerodane-type diterpenes.

Abstract—The structure and stereochemistry of teucrins H1, H2, H3 and H4, four novel diterpenes from *Teucrium hyrcanicum* have been established by detailed studies of the PMR and ^{13}C NMR spectra, CD results and chemical transformations. Teucrin H4, a minor constituent is shown to possess a unique stereochemistry hitherto not reported for related diterpenoids.

INTRODUCTION

Recently, we reported the isolation of four novel diterpenoid furolactones from the acetone extract of *Teucrium hyrcanicum* [1]. On the basis of preliminary spectral (IR, MS, PMR) data and chemical information, teucrin H1 (**1a**), the major constituent, and teucrin H4 (**3a**), the most polar one, were shown each to possess, besides the furolactone unit, an α,β-unsaturated γ-lactone, a secondary methyl and an easily acetylated hydroxyl group, and thus a structural relationship of these two molecules with other known rearranged labdane type furanoid norditerpenes [2–5] had been anticipated. On similar grounds, teucrin H2 (**4a**) featuring a secondary hydroxyl and an additional saturated γ-lactone, was suggested to be structurally related to teucrin E, a furanoid diterpene from *Teucrium chamaedrys* [6]. Finally, the preliminary results indicated that teucrin H3 (**6a**) contained the characteristic furolactone unit, a secondary methyl and an acetoxy group. Further studies (*vide infra*) showed (**6a**) to be structurally related to pikropolin which had been isolated from *Teucrium polium* and characterized (without stereochemical details) by Brieskorn and Pfeuffer [7].

The present communication deals with the structure and stereochemistry of teucrins H1–H4 as studied by PMR, ^{13}C NMR and CD spectroscopy.

RESULTS AND DISCUSSION

Teucrin H1 (**1a**)

Structure. Careful analysis of the PMR spectra (Table 1), combined with the prior knowledge [1] of the structure mentioned above, led to the identification of partial structures (**I**), (**II**) and (**III**), to which the respective ^{13}C resonances could be consistently assigned (Table 2).

The proton sequences in these partial structures were inferred from the chemical shifts and ^{1}H-^{1}H coupling information derived from extensive double resonance experiments. Distinction between the location of the hydroxyl function and the unsaturated lactone oxygen readily followed from the PMR data of the acetylated derivative (**1b**). The ^{1}H chemical shift value indicated an allylic position for C-10H while its long range couplings with C-6H and C-3H, as well as the long range coupling between C-6H and C-3H, showed that structures (**I**) and (**II**) are fused as in (**IV**). This was supported by ^{13}C NMR observations: acetylation of the —OH group gave rise to β acetylation shift of the resonance due to C-4 and γ acetylation shift of the resonances due to C-5 and C-18. (The β and γ acetylation shifts of C-2 and C-1 resonances, respectively, were also noted.) The only structure that accommodates both (**III**) and (**IV**) and at the same time remains consistent with chemical and spectral evidence (disregarding the actual stereochemistry) is obviously **1a**. Chemical transformation of teucrin H1 gave additional support to this conclusion. Alcoholysis of **1a** in alkaline medium and subsequent methylation gave, via dehydration, product **2b** identified by its IR, MS, PMR and ^{13}C NMR data. Formation of the α,β-unsaturated ester and the oxo function obviously requires an arrangement of the substituents as in **1a**, while the vicinal coupling (J = 5 Hz) between C-5H and C-10H confirms the fusion of rings A and B.

Stereochemistry. The PMR and ^{13}C NMR and CD results show that, for the common chiral centres, the relative and absolute configurations in **1a** are identical with those reported for teucvidin [4, 5]. This may be seen from the following arguments.

According to the ^{1}H-^{1}H couplings, axial orientation with respect to ring B was found for C-6H, C-8Me and C-10H. On similar grounds, the steric disposition of C-3(OH), responsible for the new chiral centre is pseudo axial.

Similarly to the case of teucvidin [4], the CD spectrum of **1a** shows (–) Cotton effect at *ca* 230 nm. This proved the identity of the absolute configurations of both molecules at C-6. Moreover, earlier studies on related furolactone diterpenoids of known geometry [4, 5] have shown that the ^{1}H chemical shift values of the C-6H,

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Table 1.* PMR chemical shifts† and coupling constants (in Hz)

	1a‡	1b‡	3a§	3b§	4a§	4b‡	6a§
C-1H	1.7, 1.95 $^2J_{1a,1e}=12.5$	1.7, 1.9	1.62, 2.4 $^2J_{1a,1e}=13$ $^3J_{2,1a}+$ $^3J_{2,1e}=13.5$	||	||	||	||
C-2H	1.82, 2.18	||	4.18 $^3J_{2,3a}+$ $J_{2,3e}=15.5$	5.20 $^3J_{2,3a}+$ $^3J_{2,3e}=15.5$	||	||	||
C-3H	4.60 $^3J_{3,2a}=3$ $^3J_{3,2e}=3$	5.67 $^3J_{3,2a}=3$ $^3J_{3,2e}=3$	2.4, 2.8	2.4, 2.8	1.88	||	1.85
C-4H					2.79 $^3J_{4,3a}=10$ $^3J_{4,3e}=7$	2.4	
C-6H	5.03 $^3J_{6,7a}=11$ $^3J_{6,7e}=6.5$ $^5J_{6,3e}=2$	5.05 $^3J_{6,7a}=11$ $^3J_{6,7e}=6.5$ $^5J_{6,3e}=2$	5.70 $^3J_{6,7a}=13$ $^3J_{6,7e}=6$ $^5J_{6,3a}=4$ $^5J_{6,3e}=2$	5.73 $^3J_{6,7a}=13$ $^3J_{6,7e}=6$ $^5J_{6,3a}=4$ $^5J_{6,3e}=2$	3.80 $^3J_{6,7a}=3$ $^3J_{6,7e}=2$	4.91 $^3J_{6,7a}=3$ $^3J_{6,7e}=2.5$	
C-7H	1.57, 2.34 $^2J_{7a,7e}=13$ $^3J_{7a,8}=4$ $^3J_{7e,8}=3$	1.62, 2.4 $^2J_{7a,7e}=13$ $^3J_{7a,8}=4$ $^3J_{7e,8}=3$	1.8, 2.1 $^2J_{7a,7e}=12.5$ $^3J_{7a,8}=9$	1.7, 2.05 $^2J_{7a,7e}=12.5$ $^3J_{7a,8}=9$	1.69, 2.30 $^2J_{7a,7e}=13$ $^3J_{7a,8}=3$ $^3J_{7e,8}=1$	1.90, 2.27 $^2J_{7a,7e}=13.5$ $^3J_{7a,8}=3$ $^3J_{7e,8}=1$	2.05, 3.44 $^2J_{7a,7e}=16$ $^3J_{7a,8}=12$
C-8H	2.20 $^3J_{8,17}=7$	2.20 $^3J_{8,17}=7$	2.30 $^3J_{8,17}=7$	2.28 $^3J_{8,17}=7$	2.15 $^3J_{8,17}=6.5$	2.05 $^3J_{8,17}=6.5$	1.9 $^3J_{8,17}=6.5$
C-10H	3.25 $^3J_{10,1a}=10$ $^3J_{10,1e}=4$ $^5J_{10,3e}=1$ $^4J_{10,6}=0.8$	3.30 $^3J_{10,1a}=10$ $^3J_{10,1e}=4$ $^5J_{10,3e}=1$ $^4J_{10,6}=0.8$	2.83 $^3J_{10,1a}=11$ $^4J_{10,6}=2$	2.9	||	||	||
C-11H	1.92, 2.70 $^2J_{11A,11B}=14$ $^3J_{11A,12}=7$ $^3J_{11B,12}=8.5$	1.90, 2.71 $^2J_{11A,11B}=14$ $^3J_{11A,12}=7$ $^3J_{11B,12}=8.5$	2.38, 2.75 $^2J_{11A,11B}=14$ $^3J_{11A,12}=10$ $^3J_{11B,12}=7$	2.36, 2.75 $^2J_{11A,11B}=14$ $^3J_{11A,12}=10$ $^3J_{11B,12}=7.5$	2.44 $^2J_{11A,11B}=14$ $^3J_{11A,12}=8.5$ $^3J_{11B,12}=8.5$	2.43 $^2J_{11A,11B}=14$ $^3J_{11A,12}=8.5$ $^3J_{11A,12}=8.5$	2.46, 2.52 $^2J_{11A,11B}=14$ $^3J_{11A,12}=8.5$ $^3J_{11B,12}=8$
C-12H	5.42	5.40	5.44	5.44	5.33	5.35	5.52
C-14H	6.38	6.37	6.42	6.40	6.41	6.44	6.42
C-15H							
C-16H	7.43	7.44	7.48	7.47	7.43	7.47	7.41
17-CH_3	1.34	1.35	1.21	1.23	0.98	0.98	1.06
C-18H	—	—	—	—	—	—	2.22, 3.47 $^2J_{18A,18B}=5.5$ $^4J_{18B,3}=2.5$
C-19H	—	—	—	—	4.38, 4.49 $^2J_{19A,19B}=11$	4.37, 4.52 $^2J_{19A,19B}=11$	4.94, 5.44 $^2J_{19A,19B}=12.5$
$OCOCH_3$	—	2.07	—	2.10	—	2.09	2.01

* Spectral parameters were obtained by first order approximation.
† In δ ppm, relative to internal TMS.
‡ In $CDCl_3$.
§ $CDCl_3$–DMSO-d_6 (4:1).
|| Not measured.

C-10H and C-8Me protons reflect their steric disposition relative to the C(9)-C(20) bond. Since the respective data of **1a** are in complete agreement with the values published for teucvidin [4], identity of the absolute configurations at C-8, C-9 and C-10 may also be safely concluded.

Of the possible two half-chair conformations of ring A, the one with the axial C-1H in α orientation must be discarded because of the nearly eclipsed disposition of C-1H_{ax} and C-10H and therefore the pseudo axial orientation of C-3(OH) should correspond to the β configuration.

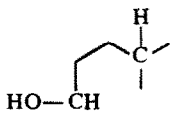
The constitution and stereochemistry of teucrin H1 are thus best represented by formula **1a**. It must be noted, however, that the spectroscopic methods used in the

Table 2. ^{13}C NMR chemical shifts (ppm from internal TMS)*

Carbon	1a	1b	3a	3b	4a	4b	6a	2b
C-1	17.43	18.14	33.36	29.55	22.92	22.82	22.99	21.23
C-2	30.61	27.59	68.25	70.20	24.37	24.08	24.38	26.54
C-3	58.01	61.12	29.20	25.85	24.81	24.69	32.76	128.94
C-4	128.93	125.61	122.85	122.56	43.97	44.06	53.93	140.07
C-5	165.30	167.99	166.68	165.79	47.54	46.50	61.04	46.64
C-6	75.67	75.83	76.53	76.46	68.12	71.35	205.83	208.38
C-7	35.57	35.60	31.77	31.82	34.40	30.77	43.66	45.17
C-8	38.64	38.47	35.88	36.29	32.72	33.52	40.83	33.86
C-9	51.97	52.08	50.92	50.87	51.34	51.16	51.51	51.22
C-10	36.27	36.02	41.67	41.28	41.45	42.87	54.57	41.15
C-11	38.55	38.36	42.21	42.52	42.15	42.07	42.56	36.62
C-12	72.06	71.96	71.63	71.69	72.07	72.09	71.83	70.97
C-13	125.49	125.36	124.34	124.25	125.00	125.00	124.99	124.12
C-14	108.31	108.06	108.05	107.90	108.08	108.05	108.19	108.12
C-15	139.81	139.62	140.20	139.99	139.62	139.66	139.98	139.81
C-16	144.13	144.45	144.26	144.43	144.21	144.33	144.19	144.25
C-17	14.12	14.27	17.51	17.58	16.56	16.44	16.98	17.15
C-18	171.59	170.14	172.94	172.20	178.41	177.17	47.99	166.53
C-19	—	—	—	—	70.77	69.90	62.04	—
C-20	177.62	177.18	176.07	175.63	177.47	177.27	176.81	177.13
Ac-Me	—	21.08	—	21.15	—	21.10	20.60	—
Ac-CO	—	169.74	—	170.45	—	169.77	170.05	—
COOMe	—	—	—	—	—	—	—	51.83

* In $CDCl_3$–DMSO-d_6 (4:1).

present work furnished no direct information with regard to the configuration at C-12. Assignment of the stereochemistry at this particular chiral centre is based, in this and subsequent cases, on the identity (or dissimilarity) of the PMR and ^{13}C NMR parameters of the C-12H methine group with the values reported on related furolactone diterpenoids of known configuration at C-12 [3–5].



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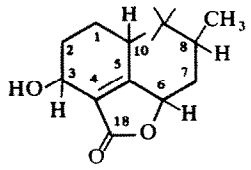

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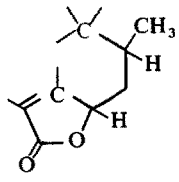

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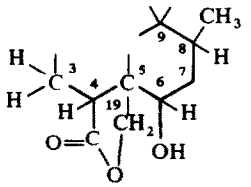

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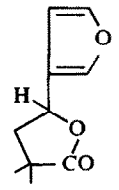

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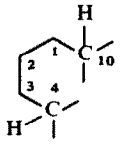

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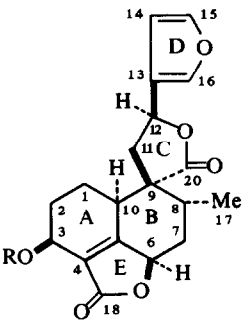
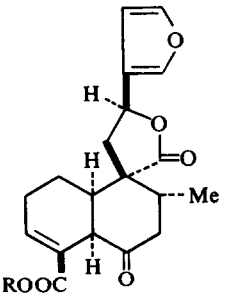


1a R = H
1b R = Ac



2a R = H
2b R = CH_3

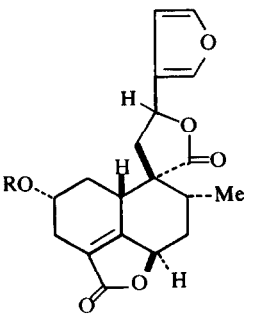
Teucrin H4 (**3a**)

Structure. Based on arguments similar to those outlined for teucrin H1, the PMR and ^{13}C NMR data (Tables 1 and 2) permitted us to define the molecular framework of this molecule, represented (disregarding stereochemical details) by formula **3a**. In this procedure, as in the case of **1a**, the occurrence of a long range ^1H-^1H coupling between C-6H and C-10H, and long range couplings between C-6H and C-3 methylene protons, as well as the acetylation shifts in the ^1H and ^{13}C NMR spectra proved to be of particular assistance.

Stereochemistry. The steric disposition of substituents relative to rings A and B follows from the ^1H-^1H couplings to the respective geminal protons. According to data in Table 1, the C-2(OH) and C-8Me groups are equatorial, whereas the orientation of C-6H is axial.

The CD spectrum of **3a** in ethanol showed (−) Cotton effect at *ca* 220 nm, which differed from that of **1a** in its higher intensity. The negative sign indicates that the absolute configuration at C-6 is identical (α) in both molecules. According to current theories of the CD spectra [8], the enhanced intensity of the Cotton effect may be ascribed to an increased distortion of the α,β-unsaturated γ-lactone.

The configurations at the other chiral centres were deduced by comparing the pertinent PMR data with the values reported on related molecules of known geometry [2–5]. Thus, following the well-established trends in the ^1H chemical shifts of the C-6H in related compounds [2–5], the observed large value (5.70 ppm) showed unambiguously that the C-6H and C(9)-C(20) bonds are in a *cis* relationship, i.e. both are α oriented. By a similar argument, the chemical shift of the C-10H (2.83 ppm) required a *trans* arrangement of C-10H and C(9)-C(20) bonds, i.e. β configuration at C-10. Indirect support in favour of the above stereochemical assignment is available from the published PMR data on related *cis* configured 6α10α and 6β10β molecules, which comprise all possible combinations of configuration at C-8 and C-9 [2–5]. The PMR data measured for teucrin H4 differ substantially from the values reported on each of these molecules, a fact which obviously could not be the case with a *cis* 6,10 configuration.



3a R = H
3b R = Ac

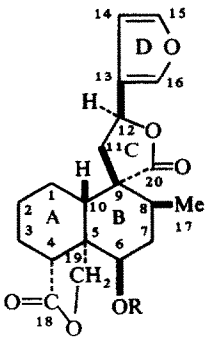
Molecular models show that the 6α10β *trans* arrangement of the carbon skeleton involves a simultaneous change in the preferred ring B conformation with respect to that determined for the *cis* molecules [9]. Molecular models reveal that in this conformation C-8Me is α oriented and the internuclear distance between C-6H and 20-CO is decreased. The latter fact may explain the large downfield shift of C-6H resonance mentioned above.

It is noteworthy that the stereochemical differences between **1a** and **3a** are also reflected by the ^{13}C chemical shift data. Resonances due to C-1, C-6, C-10, C-11 and C-8Me in **1a** appear to be more shielded than in the isomeric **3a**. Most of these diamagnetic shifts are due to 1,3-diaxial interactions of the C-8Me group with C-6H and C-10H, respectively. The relative high shielding of C-1 in **1a** may be partly due to 1,3-diaxial interactions with C-3(OH) and C-11 methylene groups, the rest of the shift difference, *ca* 8 to 9 ppm, is associated with the β OH substituent effect in **3a**. Conversely, the increased chemical shift of C-11 in **3a** can be fully explained by the decreased mutual steric interaction of the C-11 and C-1 methylene groups.

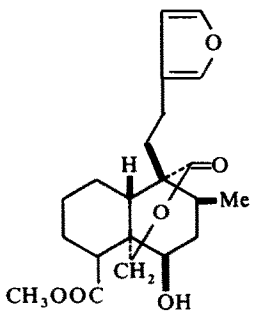
The data in Table 1 show that the ^1H-^1H couplings of C-12H in **3a** are different from the values found for **1a**, **4a** and **6a** or the values reported in the literature on related diterpenoid furolactones [2–4]. Also, the ^{13}C chemical shift of C-13 in **3a** differs by *ca* 1 ppm from its value found in **1a**, **4a** and **6a**. Both these changes might indicate an opposite configuration at C-12. However, this conclusion needs further confirmation and thus formulation of **3a** at this chiral centre leaves the stereochemistry of teucrin H4 undefined.

Teucrin H2 (**4a**)

Structure. Partial structures (**III**) and (**V**) were readily identified on the basis of previously established struc-



4a R = H
4b R = Ac



5

tural details (*vide supra*), PMR and ^{13}C NMR parameters (Tables 1 and 2) and correlations between PMR and ^{13}C NMR spectra were derived from selective and non-selective ^{13}C-{^1H} double resonance experiments. The location of the second saturated γ-lactone ring in (**V**) followed from the occurrence of γ acetylation shift in the C-19 resonance of the acetylated derivative (**4b**). The presence of partial structure (**VI**) in teucrin H2 was inferred from the following observations. The ^{13}C NMR spectra revealed three methylene carbon resonances between 20 and 25 ppm with strongly coupled ^1H spin systems. ^{13}C chemical shift arguments and the appearance of the ^{13}C-{^1H} multiplets under partially decoupled conditions required that the methylene group form an alkane chain that is terminated by the two available methine groups (δ_C 41.45 and 43.97 ppm). Selective ^{13}C-{^1H} decoupling experiments at 2.79 ppm proved the identity of the methine carbons labelled C-4 in both (**V**) and (**VI**). The γ acetylation shift of the C-10 resonance noted in the spectrum of **4b**, on the other hand, located the angular position of this carbon and thereby proved the decaline skeleton of the molecule.

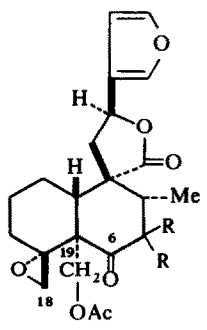
Stereochemistry. The ^1H-^1H couplings of C-6H and C-8H showed that the substituents of these positions are axially oriented. The same orientation of the substituents was mirrored by the ^{13}C chemical shift of C-10. Its higher (by *ca* 13 ppm) shielding in **4a** with respect to the value found for **6a**, (the other diterpene with saturated A/B rings), may be accounted for by considering the 1,3 diaxial interactions of C-10H with C-8Me and C-6(OH) groups. The syn-diaxial arrangement of C-6(OH) and C-8Me, giving rise to steric δ effects [10], on the other hand, readily accounts for the deshielding of the C-8Me carbon.

The splitting of the C-4H (2.79 ppm, 10 and 7 Hz) showed that the lactone ring junction is equatorial with respect to ring A. The stereochemistry of the other junction (C-5) and that of the A/B ring fusion followed from chemical evidence. Catalytic hydrogenation of teucrin H2 over Pd/$BaSO_4$ and subsequent methylation of the new carboxylic function led to the formation of **5**. The IR spectrum of this molecule attested to the conservation of the furan ring and OH group, and the cleavage of two γ-lactones. The absorptions at 1730 and 1720 cm^{-1} (shoulder), on the other hand, were attributable to a δ-lactone and an ester carbonyl, respectively. Formation of a δ-lactone via hydrogenolysis was further supported by the PMR spectrum of **5** exhibiting an AB pattern at 3.96 and 4.70 with ^2J = 13 Hz. The increased value of the geminal coupling constant relative to ^2J = 11 Hz in **4a** is readily explained in terms of increased ring-size of the δ-lactone [11]. The formation of a δ-lactone requires participation of the C-20 carbonyl group of the hydrogenolysis product, while the carbonyl at C-4 gives the methyl ester in **5**. In terms of stereochemistry for **4a**, these observations indicate that the C-20 lactone carbonyl and the C-19 methylene group are both axially oriented and, consequently, the A/B ring junction is *trans*. It may be noted that, on biogenetic grounds, the observed *trans* relationship between the C-20 carbonyl and C-8Me is unexpected. However, recent studies on rearranged labdane type norditerpenes isolated from *Croton caudatus* [5] demonstrate that molecules with the unusual *trans* arrangement of the relevant groups may co-occur with molecules in which the relative orientation is the 'regular' *cis*.

In the present study, the absolute configuration of the molecule has not been established, therefore formula **4a** represents the stereochemistry of one of the enantiomers.

Teucrin H3 (**6a**)

Structure. Analysis of PMR, ^{13}C NMR and MS* data (Tables 1 and 2) disclosed the elemental composition ($C_{22}H_{26}O_7$) and based on arguments similar to those outlined above, the molecular skeleton (**6a**) of this furolactone was verified. The occurrence of an 'isolated' AB pattern in the PMR spectrum (δ_H 4.94 and 5.44 ppm,



6a R = H
6b R = D

* Because of the easy loss of a CH_2O group, preliminary MS failed to give the correct molecular formula.

J_{AB} = 12.5 Hz) and the presence of the m/e = M-73 peak in the MS showed that the molecule contained the structural unit $>C-CH_2-$ OCOMe. The position of the oxo group (IR: 1725 cm^{-1}, ^{13}C NMR: 205.83 ppm) was readily identified through its adjacent methylene ^1H resonances exhibiting the characteristic large geminal coupling (^2J = 16 Hz) while being vicinally coupled to C-8H. Deuteration of **6a** yielded the dideuterio derivative (**6b**) (m/e = 404, M^+) which indicated that C-5 is quarternary. This result obviously places the acetoxy-methylene group at C-5.

PMR and ^{13}C NMR observations disclosed the presence of a spiro-epoxide ring located on the decaline moiety with only one methylene group being adjacent. Teucrin H3 has two methylene carbons resonating at higher fields ($\delta_C \leqslant 25$ ppm). It can be easily seen that, because of the expected β substitution effects, any position of the oxirane ring junction would leave only one methylene resonance in this chemical shift range. ^1H-{^1H} and selective ^{13}C-{^1H} double resonance experiments provided further corroboration to this statement.

Stereochemistry. PMR parameters (Table 1) indicated an equatorial orientation of C-8Me. Also, its ^{13}C chemical shift value (16.98 ppm) compared well with that found for the equatorial C-8Me in **3a**. The stereochemistry of the oxirane ring junction followed from the observed long range ^1H-^1H coupling (^4J = 2.5 Hz) of the lower field oxo-methylene proton (3.47 ppm). Similar 'epoallylic' interaction with one of the protons of the adjacent methylene group has been shown to occur only when the C(4)-C(18) bond of the spiro-epoxide ring is pseudo axially oriented with respect to the six-membered ring [12]. Comparison with literature data on related systems [12–14] shows that the large chemical shift difference of the oxirane methylene protons observed for **6a** is due mainly to the anisotropy effect to the C-6 carbonyl group. The near-coplanarity of the two functions, required for this effect to operate, may only arise if the A/B ring junction is *trans*.

Orientation of the C(9)-C(20) bond was derived from ^1H chemical shift values of the C-7 methylene protons. The considerable paramagnetic shift of the axial C-7H (3.44 ppm) relative to that of the equatorial C-7H (2.05 ppm) may be rationalized, as in the case of methyl teucvinate [4], in terms of the anisotropy effects of the lactone CO group. The proximity of the C-20 carbonyl and C-7H_{ax}, necessary for this effect to occur, requires the axial orientation of the C(9)-C(20) bond and evidently, a preferred chair conformation of ring B.

The CD spectrum of **6a** in ethanol showed a (−) Cotton effect at *ca* 300 nm. According to literature data on 6-oxo-clerodanes and related systems [15, 16], this shows that the absolute configuration of the chiral centres of teucrin H3 should be represented as in formula **6a**.

EXPERIMENTAL

Mps are uncorr. and were determined on a Boetius 72 hot-stage apparatus. Specific rotations refer to solns in EtOH, unless otherwise stated. Kieselgel 80–100 mesh was used for CC. Plates coated with Si gel or if not specified, prefabricated Kieselgel plates were used for TLC. Iodine vapour or Ehrlich reagent were employed as the developing agents. Unless stated otherwise, IR spectra were recorded in $CHCl_3$. UV spectra were obtained in EtOH. NMR spectra were obtained on Varian A-60A and XL-100-15 FT instruments. CD measurements were performed at room temp. on a Jobin-Yvon-Roussel-Jouan model III dichrograph using spectral grade EtOH. Satisfactory analysis was obtained for each compound reported.

Teucrin H1 (**1a**). UV λ_{max}^{EtOH} nm (log ε): 215 (4.23). CD (*c* 0.1, EtOH): $[\theta]_{260}$ 0, $[\theta]_{226.5}$ −54 500, $[\theta]_{211}$ 0, $[\theta]_{201.5}$ + 28 100, $[\theta]_{190}$ 0.

Alcoholysis of teucrin H1 (**1a**) *into* (**2a**). Teucrin H1 (**1a**) (200 mg) in 2% MeOH soln of KOH was refluxed for 30 min. Evapn of the solvent gave a residue (IR ν_{max}^{film} 3400 (br), 1690, 1655, 1565, 1600, 1505 cm^{-1}) which was acidified by dil. HCl and extracted by EtOAc. The extract was washed with H_2O and dried over Na_2SO_4. Evapn gave a white amorphous deposit (190 mg) which was chromatographed on a Si gel column (8 g). Elution with $CHCl_3$–MeOH (98:2) yielded **2a** (120 mg) as a white amorphous material, $C_{19}H_{20}O_6$, mp 130–133° (from EtOH–Et_2O). $[\alpha]_D^{20}$ + 104.27° ± 4.16° (*c* 0.12; EtOH). R_f 0.5 (TLC on Si gel, C_6H_6–dioxane–HOAc, 90:25:1). IR ν_{max} cm^{-1}: 3520, 3160, 1765, 1720, 1697, 1660, 1605, 1510, 880. UV λ_{max}^{EtOH} nm (log ε): 208 (4.42). MS m/e: 344 (M^+).

Methylation of (**2a**) *into* (**2b**). To a soln of **2a** (32 mg) in MeOH (2 ml) an excess of CH_2N_2 in Et_2O was added and left for 6 hr. Evapn of the solvents gave a residue which was purified by CC (Si gel, 6 g). Elution with $CHCl_3$ yielded **2b** (15 mg) $C_{20}H_{22}O_6$, mp 172–173° (from EtOH). $[\alpha]_D^{20}$ + 73.06° ± 1.25° (*c* 0.4; $CHCl_3$). R_f 0.9 (TLC on Si gel, $CHCl_3$–MeOH, 19:1). R_f 0.7 ($CHCl_3$–Et_2O, 17:3). IR ν_{max} cm^{-1}: 3160, 1770, 1720, 1665, 1605, 1510, 880. UV λ_{max}^{EtOH} nm (log ε): 210 (4.03). MS m/e: 358 (M^+), 326 (M-32), 298, 232, 220, 95, 81.

Teucrin H4 (**3a**). UV λ_{max}^{EtOH} nm (log ε): 217 (4.09). CD (*c* 0.1, EtOH): $[\theta]_{280}$ 0, $[\theta]_{249}$ + 28 200, $[\theta]_{239}$ 0, $[\theta]_{22.5}$ − 84 500, $[\theta]_{203}$ 0, $[\theta]_{190.5}$ + 41 300.

Catalytic hydrogenation of teucrin H2 (**4a**) *and subsequent methylation to* **5**. Teucrin H2 (**4a**) (300 mg) was hydrogenated for 8 hr in 96% EtOH (20 ml) over 5% Pd–$BaSO_4$ (70 mg). After filtering and evapn of the solvent, the residue was dissolved in $CHCl_3$ (15 ml) and the acidic fraction was separated by treatment with 5% Na_2CO_3 soln. The aq. soln was acidified by dil. HCl (1:3) and extracted with $CHCl_3$. The $CHCl_3$ extract was washed with H_2O until neutrality and dried over Na_2SO_4. Evapn of the solvent left a residue which was dissolved in MeOH (2 ml). After addition of excess CH_2N_2 in Et_2O the soln was left for 6 hr at room temp. The reaction gave the unconverted parent molecule (180 mg) and compound **5** (75 mg) as a glassy solid, $C_{21}H_{28}O_6$. $[\alpha]_D^{24}$ − 48.49° ± 0.68° (*c* 0.73). R_f 0.56 ($CHCl_3$–MeOH, 19:1). IR ν_{max} cm^{-1}: 3610, 1730, 1720 (sh), 1605, 1510, 1155, 1030, 880. UV λ_{max}^{EtOH} nm (log ε): 209 (4.79). MS m/e: 376 (M^+) 358, 345, 303, 299, 298, 295, 282, 250, 232, 222, 95, 81.

Teucrin H3 (**6a**). UV λ_{max}^{EtOH} nm (log ε): 211 (3.74). CD (*c* 0.1, EtOH): $[\theta]_{300}$ − 1680, $[\theta]_{225}$ − 1320, $[\theta]_{221}$ 0, $[\theta]_{208}$ + 4800, $[\theta]_{195}$ + 9600.

Deuteration of ketone **6a**. To a soln of **6a** (20 mg) in absolute dioxane (0.5 ml) deuterium oxide (0.2 ml) and dry Na_2CO_3 (15 mg) was added and the mixture was left for 36 hr at room temp. The mixture was filtered, acidified by dil. HCl and extracted with $CHCl_3$. The collected extracts were washed with H_2O until neutrality, dried over $NaSO_4$ and the solvent was evapd. The work-up procedures were repeated 3×. Recrystallization from EtOH gave the dideuterio derivative **6b** (18 mg), $C_{22}H_{24}D_2O_7$, mp 216–218°. MS m/e: 404 (M^+).

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REFERENCES

1. Oganessian, G. B. and Mnatsakanian, V. A. (1977) *Khim. Prir. Soedin.*, 215.
2. Popa, D. P. and Reinbol'd, A. M. (1973) *ibid.*, 31. Popa, D. P., Reinbol'd, A. M. and Rezvukhin, A. I. (1973) *ibid.*, 169.
3. Fujita, E., Uchida, I. and Fujita, T. (1974) *J. Chem. Soc. Perkin Trans. 1*, 1547.

4. Uchida, I., Fujita, T. and Fujita, E. (1975) *Tetrahedron* **31**, 841.
5. Chatterjee, A., Banerjee, A. and Bohlmann, F. (1977) *Tetrahedron* **33**, 2407.
6. Reinbol'd, A. M. and Popa, D. P. (1974) *Khim. Prir. Soedin.*, 589.
7. Brieskorn, C. H. and Pfeuffer, T. (1967) *Chem. Ber.* **100**, 1998.
8. Snatzke, G. and Snatzke, F. (1973) in *Fundamental Aspects and Recent Developments in Optical Rotatory Dispersion and Circular Dichroism* (Giardelli, F. and Salvadori, P., eds.). Heyden and Sons, London.
9. Uchida, I., Fujita, E., Taira, Z. and Osaki, K. (1974) *Cryst. Struct. Commun.* **3**, 569.
10. Grover, S. H. and Stothers, J. B. (1974) *Can. J. Chem.* **52**, 870.
11. Bhacca, N. S. and Williams, D. H. (1964) in *Applications of NMR Spectroscopy in Organic Chemistry*. Holden-Day, San Francisco.
12. Joseph-Nathan, P. and Diaz, E. (1971) *Org. Magn. Reson.* **3**, 193.
13. Hosozawa, S., Kato, N. and Munakata, K. (1974) *Phytochemistry* **13**, 308.
14. Hosozawa, S., Kato, N. and Munakata, K. (1974) *Phytochemistry* **13**, 1019.
15. Hosozawa, S., Kato, N. and Munakata, K. (1974) *Tetrahedron Letters*, 3753.
16. Barton, D. H. R., Cheung, A. T., Cross, A. D., Jackman, L. M. and Martin-Smith, M. (1961) *J. Chem. Soc.* 5061.