PROTON MAGNETIC RESONANCE SPECTRA OF PTEROCARPAN AND RELATED PHYTOALEXINS

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Abstract - Proton magnetic resonance spectral data of pterocarpan and related *phytoalexins are reviewed.*

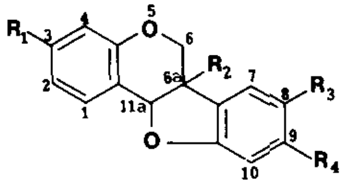
Many plants respond to invasion by both pathogenic and nonpathogenic microorganisms by producing low molecular weight antibiotics termed as phytoalexins[1-4]. These antimicrobial compounds are also produced following an interaction between plants and various biotic[5-10] and abiotic agents[11-59], which act through the same mechanisms[23, 60]. The genetic information for phytoalexin production is carried by the host and elicitors of such production, whether specific or nonspecific act through the host genume. Thus a given species may produce the same phytoalexins irrespective of the challenging agent.

The accumulation of phytoalexins may be responsible for cessation of fungal development which has suggested that these compounds may have a role in disease resistance[61-66]. Phytoalexins are mainly produced by members of the Leguminosae and Solanaceae family of plants during the first few hours of the penetration of the parasitic cells into the invaded tissue[67-69]. Oxygen heterocyclic phytoalexins having a 6a,11a-dihydro-6H-benzofurobenzopyran nucleus such as (1) called pterocarpans and other flavonoid and closely related C_6C_3 derived compounds are mainly elaborated by plants belonging to Leguminosae, while terpenoid phytoalexins are mainly produced by plants belonging to Solanaceae family.

Nuclear magnetic resonance (NMR) spectroscopy has played a major role in the structural elucidation of both benzenoid and terpenoid phytoalexins. The conformation of the 6a,11a-dihydro-6H-benzofuro[3,2-C]-(1)-benzopyran ring system (1) in pterocarpans by NMR spectroscopy has been reported by Pachler and Underwood[10]. The conformation of the heterocyclic rings has been mainly derived from the viacinal coupling constants and observation of the long range coupling.

These compounds have two asymmetric centres and relatively unstrained cis conjunction is considered more likely. Coupling constants helped Suginome[71] and Underwood[70] to conclude that the relative configuration of these centres in the stress metabolites homopterocarpin (1) is H,H cis. The absolute configuration[72] of C_{11a} in trifolirhizin (2), a phytoalexin elaborated by clover roots[73] and Ononis spinosa[74] has been established[75] as R, and with cis relationship, the configuration of this compound will be 6a, R:11a, R.

The aromatic protons as in (4) at positions 1, 2 and 4 give rise to an ABC-type of splitting pattern. On the other hand the protons of the second aromatic ring show either a single resonance line due to the closely similar electronic environment of protons at C_7 and C_{10} or a second ABC pattern for compounds such as (2).

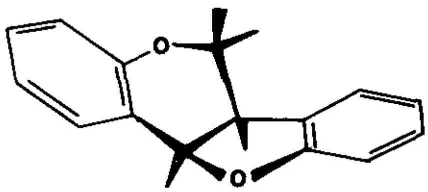


1. $R_1=R_2=R_3=R_4=H$
2. $R_1=R_4=OMe$; $R_2=R_3$ =H
3. R_1=O-glucose ; R_2=H ; $R_3+R_4=O-CH_2-O$
4. R_1=OMe ; R_2=H ; $R_3+R_4=O-CH_2-O$

Thus protons from the two aromatic rings and from the heterocyclic system form three isolated spin systems with very characteristic peak patterns. The first for proton at C_1 gives rise to a doublet ($J \sim 8.5\,H_z$) coupled to the ortho proton at C_2, which because of the additional meta coupling to a proton at C_4 ($J \sim 2.5\,H_z$), shows a quartet. The resonance from H-4 is expected to be a narrow doublet.

The second for protons at 6, 6a and 11a forms an ABMX system which gives a highly characteristic spectral pattern which has been studied for many pterocarpans[1]. While the third common factor for pterocarpans is the AB-system for protons at C_7 and C_8 (2). The quartet from these protons contains a typical aromatic ortho-coupling of $\sim 8.5\,H_z$. The deshielded doublet is assigned to the proton at C_8 because of the presence of an adjacent oxygen atom at C_9. There are four possible arrangements of the oxygen and other substituents on this aromatic ring which could produce an ortho AB-type system.

The heterocyclic ring protons gives rise to a highly complex four-spin due to strong coupling between the two protons at C_6. The H_{11a} occurs at lowest field because of diamagnetic aromatic ring currents as well deshielding by the oxygen atoms of the furan ring. The proton at position 6a occurs at highest field and couples with the low field proton at 11a. The magnitude of the viacinal coupling constants identify the protons on carbon atom 6, the axial one being nearer to the proton at H_{6a} than to its equatorial counterpart. The strong coupling between these two protons (axial on C_6 and on C_{6a}) is reported[70] to cause the complexity of the four spin spectrum. Spin coupling of the proton at C_{11a} renders the spectrum to a straightforward ABC-system. The resonance lines due to the proton on carbon 6a appears as broad, revealing a triplet fine structure at highest resolution. Double irradiation experiments have shown that the protons at C_{6a} and C_{11a} are coupled to aromatic protons across four and five bonds. The following coupling constants have been determined: $J_{6a,7} = 0.6H_z$; $J_{6a-10} = 0.5H_z$; $J_{a,11a} = 0.5H_z$; $J_{2,11a} \leq 0.1H_z$; $J_{4,11a} = 0.3H_z$. Pachler and Underwood[70], from coupling studies have concluded that the benzofuran ring system of pterocarpan exists in the folloeing conformation (5).



5.

The isopentenyl side chain and dimethylchromene ring also produce characteristic NMR patterns. The two methyl groups of the dimethylchromene ring are non-equivalent and the ethylene protons give an AB quartet ($J = 10H_z$). In the isopentenyl chain, the methyl groups bring allylic, resonate at lower field than those of the dimethylchromene ring. The remaining protons $-CH_2-CH=$ form a typical ABX system, the methylene group appearing as a doublet and the methine proton as a broad singlet. ^{1}H-NMR data for more than one hundred pterocarpan and related phytoalexins, along with their sources is tabulated in the following Tables.

<u>Stress Agents Referred in the Tables:</u>

1. Helminthosporium turcicum 2. Monilinia fructicola 3. Ascochyta pisi Lib.
4. Caldosporium sp., Phoma lingan 5. Spetoria apii 6. Per-onospora tabacina Adam
7. Uromyces fabae pers 8. Sclerotinia fructicola 9. Aphanomyces euteiches
10. Fusarium solani 11. Rhizoctonia solani 12. Helminthosporium carbonum

13. Botrytis cinerea 14. Pseudomonas spp. 15. Colletotrichum lindemuthianum

16. Uromyces appendiculatus 17. E. Sandwicensis 18. Pseudomonas phaseolicola

19. Inorganic materials 20. Phytophthora megasperma var Sojae 21. Ribonuclease-A

22. Asc-ochytaimperfecta 23. Lathyrus spp. 24. Verticillum albo atrum

25. Phytophthora drechsleri 26. Botrytis fabae 27. Pithomyces chartarum

28. Phytophthora vignae 29. Wound 30. Fusarium oxyporum 31. Cladosporium herbarum

32. Phytophthora infestans 33. Ceratosystis fimbriata 34. Fusarium coeruleum

35. Phoma exigua 36. Thielaviopsis basicola 37. Alternaria brassicicola

38. UV light 39. Actinomycin D 40. Temperature 41. Sclerotina trifoliorum

42. Cladiosporium fulvum 43. Colletotrichum *coffeanum* .

Solvents Referred in the Tables

1. Chloroform-d 2. Acetone-d_6
3. Methanol-d_4 4. Carbon tetrachloride
5. Acetonitrile-d_3 6. Dimethylformamide-d_7 + Chloroform-d
7. Dimethylsulfoxide-d_6 + Chloroform-d
8. Chloroform-d + Methanol-d_4
9. Dimethylformamide-d_7

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
PTEROCARPANS					
Pterocarpin (3-Methoxy-8,9-methylenedioxypterocarpan)	Pterocarpus santalinus, Pterocarpus dabergoides, Pterocarpus macrocarpus, Baphia nitida		1	7.4,H_1; 6.67,H_7;6.61,H_2;6.45, H_4; 6.41,H_{10}; 5.87,-O.CH_2.O; 3.73,-OMe . $J_{1,2}$=8.4; $J_{1,4}$=0.3; $J_{2,4}$=2.4; $J_{7,10}$=0.3; $J_{-O.CH_2.O}$=1.3 H_z.	76
Homopterocarpin (3, 9-Dimethoxypterocarpan)	Pterocarpus soyauxii, Pterocarpus santalinus	1	1	7.4,H_1; 7.1,H_7; 6.61,H_2; 6.45, H_4; 6.43,H_{10}; 6.42,H_8; 3.44, H_{6a}; 4.2,3.6,H_6; 5.45,H_{11a}; 3.74,-OMe; 3.72,-OMe. $J_{1,2}$=8.5; $J_{1,4}$=0.3; $J_{2,4}$=2.4; $J_{7,8}$=8.8; $J_{7,10}$=0.3; $J_{9,10}$= 2.7H_z.	70,77,78
Medicarpin (Demethylhomopterocarpin)	Melilotus alba, Medicago sativa, Canavalia ensiformis, Vigna unguiculata, Trifolium pratense, Trigonella foenum	1, 2, 12, 13, 15, 19, 20, 23, 24, 26, 27, 43	1	7.38,H_1; 7.12,H_7; 6.56,H_2; 6.45,H_{10}; 6.44,H_8; 6.42,H_4; 6.08,-OH; 5.48,H_{11a}; 4.2,H_6eq; 3.26,-OMe; 3.6,H_{6ax}; 3.52,H_{6a}.	65,70,79, 81,87,88, 166,137-153
Isomedicarpin	Psophocarpus tetragonolobus, Medicago sativa	13, 19	1	7.45,H_1; 6.66,H_2; 7.1,H_7; 6.4,$H_{4,8,10}$; 5.52,H_{11a}; 4.24, H_6 eq; 3.6,H_{6ax}; 3.8,OMe. $J_{7,8}$=8; $J_{2,4}$=2.5 H_z.	155-160
Trifolirhizin (Maackiain β-D-Glucoside)	Trifolium pratense, Ononis spinosa	1	1	7.38,H_1; 6.66.H_7; 6.6,H_2; 6.45,H_4; 6.4,H_{10}; 5.87,-O.CH_2.O-; 3.7, OMe. $J_{1,2}$=8.4; $J_{1,4}$=0.3; $J_{2,4}$=2.4; $J_{7,10}$=0.3; $J_{-O.CH_2.O}$=1.3 H_z	70,73-75, 80

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Maackiain (Demethyl-pterocarpan)	Trifolium pratense, Maackia amunensis, Trigonella foenum	1	1	7.56, H_1; 6.86, H_2; 6.49, H_4; 6.77, H_7; 6.4, H_{10}; 5.87, -O.CH_2.O-, 5.49, H_{11a}; 4.31, H_{6eq}; 6.17, H_{6ax}; 6.42, H_{6a}. $J_{1,2}$=8.0; $J_{6ax\ \&\ eq}$=11.0H_z.	70,73, 81-89
Inermin (6a-Hydroxy-maackiain)	Pisum sativum, Andira inermis, Trifolium pratense	2, 30, 3	1	7.37, H_1; 6.56, H_2; 6.43, H_4; 6.42, H_7; 6.82, H_{10}; 5.96, 5.93, -O.CH_2.O-; 5.28, H_{11a}; 4.18, H_{6eq}; 4.00, H_{6ax}. $J_{1,2}$=8; $J_{6ax\ \&\ eq}$=11.0H_z.	73,83, 90-94
Pisatin (6a-Hydroxy-pterocarpin)	Pisum sativum, Lathyrus odoratus	2-13	4	7.4, H_1; 6.5, H_2; 6.35, H_4; 6.4, H_{10}; 6.25, H_7; 5.75, -O.CH_2.O-; 5.45, H_{11a}; 4.1, H_{6eq}; 3.47, H_{6ax}.	7,45,17, 76,93, 95-115 286,297, 298
Variabilin (6a-Hydroxyhomoptero-carpan)	Lathyrus odoratus, Trifolium pratense	12,13,41	1	7.4, H_1; 6.6, H_2; 6.5, H_{10}; 6.4, H_4; 6.37, H_7; 5.45, H_{11a}; 3.86, -OMe; 3.76, -OMe; 3.65, H_{6ax}; 5.85, H_{6eq}.	96,116-118,157, 287,288, 252
Dolichin-A (3,9-Di-hydroxy-10-(2'-hydroxy-3'-methyl-3'-butenyl)-ptero-carpan)	Dolichos biflorus	14	2	7.33, H_1; 7.0, H_7; 6.55, H_2; 6.37, H_8; 6.35, H_4; 5.44, H_{11a}; 4.88, $H_{4'}$; 4.32, $H_{2'}$; 4.25, H_{6eq}; 3.55, H_{6a} & H_{6ax}; 2.87, $H_{1'}$; 1.8, $H_{5'}$.	119,289
Dolichin-B (3,9-Di-hydroxy-10-(2'-hydroxy-3'-methyl-3'-butyl)-pterocarpan)	Dolichos biflorus	14	2	7.2, H_1; 7.02, H_7; 6.55, H_2; 6.38, H_8; 6.37, $H_{2'}$; 6.35, H_4; 5.46, H_{11a}; 4.82, $H_{4'}$; 4.24, H_{6eq}; 3.55, H_{6a} & H_{6ax}; 2.81, $H_{1'}$; 1.76, $H_{5'}$.	119,289

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Tuberosin	Neorautanenia edulis, Pueraria tuberosa		1	7.27,H_1; 7.1,H_7; 6.5,H_2; 6.25,H_4; 6.2,H_{12}; 4.0,H_6; 5.25,H_{13a}; 1.3, 2 X Me.	120-123
Phaseollin	Phaseolus vulgaris, Vigna unguiculata	10,15,16, 13,2	1	7.37,H_1; 6.92,H_7; 6.54,H_2; 6.41,H_4; 6.32,H_8; 5.55,H_{11a}; 5.54,H_{13};6.48,H_{12}; 4.2 & 3.64, H_6; 3.5,H_{6a}; 1.49,$(CH_3)_2$.	19,22,63 90,124-135
Phaseollidin (3,9-Dihydroxy-10-isopentenylpterocarpan)	Phaseolus vulgaris, Vigna unguiculata Dolichos biflorus, Erythrina cristagali, Psophocarpus teragonolobus	12-15,2, 17,13,19	1	7.37,H_1; 6.93,H_7; 6.53,H_2; 6.4,H_4; 6.36,H_8; 5.44,H_{11a}; 5.28,H_{13}; 4.21, 3.63,H_6; 3.54,H_{6a}; 3.36,H_{12}, 1.81,Me; 1.76, 2 X Me.	23,126, 130,136, 219
1-O-Methylphaseollidin	Psophocarpus tetragonolobus	13,19	1	6.98,H_7; 6.37,H_8; 6.08,$H_{2,4}$; 5.6,H_{11a}; 5.36,=CH; 4.2,H_{6eq}; 3.85,H_{6ax}; 3.87,OMe; 3.4,$-CH_2$; 1.79, 1.75, 2 X Me.	158
Demethylmedicarpin	Erythrina cristagalli	12,17	1	7.58,H_1; 7.1,H_7; 6.88,H_2; 6.7,H_4; 6.4,H_{10}; 6.37,H_8.	154
3,6a,9-Trihydroxypterocarpan	Medicago sativa	19	3	7.3,H_1; 7.2,H_7; 6.55,H_2; 6.42,H_8; 6.32,H_4; 6.24,H_{10}; 5.26,H_{11a}; 4.16, 4.04,H_6. $J_{1,2}$=8.3; $J_{2,4}$=2.3; $J_{7,8}$=8.1Hz	158,159
Cristacarpin (3,6a-Dihydroxy-9-methoxy-10-isopentenylpterocarpan)	Erythrina cristagalli, Psophocarpus tetragonolobus	12	2	7.33,H_1, 7.18,H_7; 6.56,H_2; 6.54,H_8; 6.31,H_4; 5.27,H_{11a}; 5.16,=CH;4.16, 4.06,H_6 & H_{6a}; 3.25,$-CH_2$; 3.83,-OMe, 1.76,Me; 1.65,-Me. $J_{1,2}$=8.5; $J_{2,4}$=2.3; $J_{7,8}$=8.0Hz	154

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
3,6a-Dihydroxy-8,9-methylenedioxyptero-carpan	Pisum sativum	10	2	7.3,H_1; 7.18,H_7; 6.5,H_2; 6.3,H_4; 6.16,H_{10}; 5.25,H_{11a}; 4.16,H_{6eq}; 4.06,H_{6ax}.	90-94
Vesticarpan (3,10-Dihydroxy-9-methoxy-pterocarpan)	Lathyrus nissolia, Macharium vestitum, Platymiscium trini-tatis	12	2	7.39,H_1; 6.6,H_2; 7.1,H_7; 6.45,H_8; 6.37,H_4; 5.45,H_{11a}; 4.2,H_{6eq} & H_{6a}; 3.9,OMe; 3.6,H_{6ax}.	117
Methylnissolin (3-Hydroxy-9,10-di-methoxypterocarpan)	Lathyrus nissolia	12	2	7.37,H_1; 6.6,H_2; 7.08,H_7; 6.45,H_8; 6.35,H_4; 5.46,H_{11a}; 4.15,H_{6eq} & H_{6a}; 3.6,H_{6ax}; 3.87,-OMe.	117
2-Methoxymedicarpin (3-Hydroxy-2,9-di-methoxypterocarpan)	Pisum sativum	10	1	7.18,H_1; 6.96,H_7; 6.52,H_4; 6.44,H_{10}; 6.43,H_8; 5.89,OH; 3.9,OMe; 3.77,OMe. $J_{1,4}$=2.3; $J_{7,8}$=8.8H_z.	163
2,3,9-Trimethoxy-pterocarpan	Oisum sativum	10	1	7.12,H_7; 6.97,H_1; 6.47,H_4; 6.45,H_{10}; 6.44,H_8; 3.91, 3.86, 3.78, 3 X OMe. $J_{7,8}$=8.8; $J_{8,10}$=2.5H_z.	163,164
4-Hydroxy-2,3,9-trimethoxyptero-carpan	Pisum sativum	10	1	7.13,H_7; 6.61,H_1; 6.44,H_{10}; 6.44,H_8; 5.63,OH; 3.88, 3.84, 3.73, 3 x OMe. $J_{7,8}$=9; $H_{8,10}$=2.5H_z.	163
3-Hydroxy-2,9-di-methoxypterocarpan	Pisum sativum	10	1	7.12,H_7; 6.96,H_1; 6.52,H_4; 6.44,H_{10}; 6.43,H_8; 5.89,OH; 3.9, 3.77, 2 x OMe. $J_{7,8}$=8.8, $J_{8,10}$=1.3H_z.	163

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
6a,7-Dihydroxy-phaseollin	Phaseolus vulgaris	15,18	1	7.1,H_1; 6.8-6.3,$H_{2,4,8}$; 6.36,=CH at C_{12}; 5.4,=CH at C_{13}; 5.26,H_{11a}; 5.24,H_6; 4.77,H_{11a}; 1.33, 1.3, 2 x Me. $J_{12,13}$=10; $J_{1,2}$=8H_z.	221-223, 182
6a-Hydroxyphaseollin	Phaseolus vulgaris	15,18	5	7.11,H_1; 7.32,H_7; 6.7-6.3, $H_{2,4,8}$; 6.41,=CH at C_{12}; 5.64,=CH at C_{13}; 5.3,H_{11a}; 4.04,H_6; 1.37, 1.33, 2 x Me.	221-223, 182
1a-Hydroxyphaseollone	Phaseolus vulgaris	10	1	6.88,H_7; 6.69,H_1; 6.32,H_8; 6.22,H_{12}; 6.09,H_2; 5.48,H_4; 5.48,H_{13}; 5.14,H_{11a}; 5.08,H_{6eq} 4.33,H_{6ax}; 3.91,H_{6a}; 1.37, 2 x Me. $J_{1,2}$=10; $J_{6ax,eq}$=10; $J_{7,8}$=8.5; $J_{12,13}$=10H_z.	135
3-Hydroxy-4,9-di-methoxypterocarpan	Trifolium cherleri	12	2	7.13,H_7; 6.96,H_1; 6.6,H_2; 6.4,H_{10}; 6.39,H_8; 3.95, 3.9, 2 x OMe.	165
Glyceollin-V (3, 6a,9-Trihydroxy-pterocarpan)	Glycine max	14,19,20	2	7.3,H_1; 7.2,H_7; 6.55,H_2; 6.42,H_8; 6.32,H_4; 6.26,H_{10}; 5.26,H_{11a}; 4.16 & 4.04,H_6 $J_{1,2}$=8.3; $J_{2,4}$=2.5; $J_{7,8}$=8.3; $J_{6ax,eq}$=11.6H_z.	167-176
Glyceollin-IV (3-Methoxy-6a,9-di-hydroxy-2-isopen-tenylpterocarpan)	Glycine max	19,20	2	7.2,H_7; 7.18,H_1; 6.42,H_8; 6.4,H_4; 6.25,H_{10}; 5.24,H_{13}; 5.2,H_{11a}; 4.13 & 4.01, H_6; 3.79, OMe; 1.72, 2 x Me. $J_{7,8}$=8.6; $J_{8,10}$=2.1, $J_{6a\&eq.}$= 11.4; $J_{12,13}$=7.2H_z.	159,174

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Glyceollin-III	Glycine max	19,20	2	7.27,H_1; 7.27,H_7; 6.46,H_8; 6.27,H_4; 6.26,H_{10}; 5.3,H_{11a}; 4.15, & 4.05,$H_{6ax\ \&\ eq}$. $J_{7,8}$=8; $J_{8,10}$=2; $J_{6ax\ \&\ eq}$ = 11.0H_z.	169-174
Glyceollin-II	Glycine max	19,20	2	7.15,H_1; 6.43,H_8; 6.41,H_{12}; 6.25,H_{10}; 6.21,$H_{4,7}$; 5.65,H_{13}; 5.25,H_{11a}; 4.13 & 4.04, $H_{6ax\ \&\ eq}$; 1.4, 1.37, 2 x Me. $J_{7,8}$=8; $J_{8,10}$=2; $J_{6ax\ \&\ eq}$= 12; $J_{12,13}$=10H_z.	169-173
Glyceollin-I	*Glycine max*	*14,19,20*	*2*	7.2,H_7; 7.16,H_1; 6.6,H_2; 6.42,H_8; 6.41,H_{12}; 6.25,H_{10}; 5.44,H_{13}; 5.15,H_{11a}; 4.12 & 4.01,H_6; 1.38 & 1.35, 2 x Me. $J_{7,8}$=10; $J_{8,10}$=2H_z.	169-173
Glyceocarpin	Glycine max	14	2	7.19,H_7; 7.16,H_1; 6.41,H_8; 6.36,H_4; 6.24,H_{10}; 5.4,H_{13}; 5.27,H_{11a}; 4.09 & 3.97,H_6; 3.28,H_{12}; 1.73, 2 x Me. $J_{6ax,eq}$=11; $J_{7,8}$=8; $J_{12,13}$= 7.5H_z.	183-189, 124,172 156,170, 169,176, 39
Glyceofuran	Glycine max	14	2	7.7,H_1; 7.24,H_7; 6.95,H_4; 6.63,H_{12}; 6.44,H_8; 6.24,H_{10}; 5.47,H_{11a}; 4.24 & 4.2,H_6; 1.68, 2 x Me. $J_{6ax,eq}$=11; $J_{7,8}$=8.0H_z.	183-189
Glyceofuran-9-O-*methylether*	Glycine max	14	2	7.2,H_7; 7.16,H_1; 6.9,H_4; *2.37,H_{12}; 6.34,H_8; 6.3,H_{10};* 5.45,H_{11a}; 4.23 & 2.17,H_6;	183-189

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
				1.72, 2 x Me.	
COUMESTANS					
Coumestrol (3,9-Dihydroxycoumestan)	Ladino clover, phaseollus vulgaris	14,19,21	9	7.9,H_5; 7.2-7.0 complex, $H_{6,8,10}$; 7.2-7.0 complex, $H_{11,13}$.	8,22,177, 178
9-O-Methylcoumestrol	Medicago sativa	19	9	7.7,H_5; 7.3-7.0 complex $H_{6,8,10}$; 7.2-7.0 complex, $H_{11,13}$; 3.79, OMe.	178,140
3-Hydroxy-8,9-dimethoxycoumestan	Medicago sativa	19,22	9	7.26,H_1; 7.2,H_7; 6.6,H_2; 6.4,H_4; 6.28,H_{10}; 3.79 & 3.78, 2 x OMe.	179,180
Wairol (3-Hydroxy-7,9-dimethoxycoumestan)	Medicago sativa	22	1	7.3,H_8; 7.28,H_1; 6.5,H_2; 6.4,H_4; 6.3,H_{10}; 3.8 & 3.78, 2 x OMe.	179
Repensol (3,7,9-Trihydroxycoumestan)	Ladino clover	22	6	7.31,H_8; 7.28,H_1; 6.45,H_2; 6.38,H_4; 6.25,H_{10}.	18,182
Trifoliol (3,7-Dihydroxy-9-methoxycoumestan)	Ladino clover	22	9	7.83,H_1; 7.03,H_2; 6.97,H_4; 6.42,H_8; 6.8,H_{10}; 3.82, OMe.	18,182
ISOFLAVONES AND ISOFAVANS					
Daidzein (7,4'-Dihydroxyisoflavone)	Glycine max	14	2	8.2,H_2; 8.08,H_5; 7.97,H_6; 7.0,H_8; 7.47,$H_{2',6'}$; 6.9, $H_{3',5'}$. $J_{5',6'}$=8.5; $J_{5,6}$=8.8Hz.	8,171
Isoformononetin (7-Methoxy-4'-hydroxy-isoflavone)	Glycine max	14	2	8.21,H_2; 8.1,H_5; 7.07,H_6; 7.05,H_8; 7.48,$H_{2',6'}$; 6.88, $H_{3',5'}$; 3.86, OMe. $J_{2',3'}$=8.5; $J_{5,6}$=9; $J_{5',6'}$=9Hz.	8,171

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Genistein (5,7,4'-Trihydroxyisoflavone)	Phaseolus vulgaris	2	7	8.2,H_2; 8.05,H_6; 7.03,H_8; 7.45,$H_{2',6'}$; 6.8,$H_{3',5'}$. $J_{6,8}$=2.3; $J_{2',3'}$=9; $J_{5'6'}$=9H_z.	190
7,2',4'-Trihydroxy-isoflavanone	Phaseolus vulgaris	2	2	7.74,H_5; 6.81,$H_{6'}$; 6.54,H_6; 6.45,$H_{3'}$; 6.39,H_8; 6.24,$H_{5'}$; 4.59,H_{2ax}; 4.44,H_{2eq}; 4.09,H_3. $J_{5,6}$=8.8; $J_{6,8}$=2.2; $J_{5',6'}$= 8.3; $J_{2ax,eq}$=10.7H_z.	287
7,2',4'-Trihydroxy-isoflavone	Phaseolus vulgaris	2	2	8.14,H_2; 7.93,H_5; 6.98,$H_{6'}$; 6.93,H_6; 6.86,H_8; 6.36,$H_{3'}$; 6.27, H_5. $H_{5,6}$=8.8,$H_{6,8}$=2.2; $H_{5',6'}$=8.3; $H_{3',5'}$=2.4H_z.	287
2'-Hydroxygenisten (2',4',5,7-Tetra-hydroxyisoflavone)	Phaseolus vulgaris	2	7	8.07,H_8; 7.77,$H_{6'}$; 6.36,$H_{3'}$; 6.25,$H_{5'}$; 6.12,H_6. $J_{5',6'}$=8; $J_{3',5'}$=2.4H_z.	136,191-195
Luteone [2',4',5,7-Tetrahydroxy-6(3,3-dimethylallyl)-isoflavone]	Lupinus albus	3	2	7.98,H_8; 7.75,$H_{6'}$; 6.35,$H_{3'}$; 6.2,$H_{5'}$; 5.18,=CH; 3.19,-CH_2; 1.75 & 1.65, 2 X Me. $J_{5\ 6'}$=8; $J_{3',5'}$=2H_z.	241
Isoferreirin (5,7,4'-Trihydroxy-2'-methoxyflavone	Dolichos biflorus	14		8.05,H_8; 7.75,$H_{6'}$; 6.4,$H_{3'}$; 6.25,$H_{5'}$; 6.12,H_6. $J_{5',6'}$=8; $J_{3',5'}$=2.4H_z.	289
Kievitone (2',4',5,7-Tetrahydroxy-8-isopentenyliso-flavone)	Phaseolus vulgaris, Dolichos biflorus, Ougeinia dalber-gioides, Lablab niger	2,10,11 13-15, 19	7	6.91,$H_{2'}$; 6.45,$H_{5'}$; 6.04,H_6; 6.32,$H_{3'}$; 5.18,-CH_2; 4.6, 4.16,$H_{2\ \&\ 3}$; 3.21,-CH_2; 1.74 & 1.66, 2 X Me; 9.2, 8.78, 8.59, OH. $J_{2',3'}$=8; $J_{3',5'}$=2H_z.	23,190, 195-206, 290

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Kievitone hydrate	Phaseolus vulgaris	10	3	6.97,$H_{2'}$; 6.31,$H_{5'}$; 6.25,$H_{3'}$; 5.95,H_6; 4.5,$H_{2a\ \&\ b}$; 4.15,H_3; 2.8,$H_{1''}$; 1.6,$H_{2''}$; 1.25, 2 x Me	135
Phaseoluteone [2',4',5,7-Tetrahydroxy-3'-(3,3,dimethyl-ally) isoflavone]	Phaseolus vulgaris	2	2	13.11,5-OH; 8.12,H_2; 6.9,$H_{6'}$; 6.55,$H_{5'}$; 6.46,H_8; 6.33,H_6; 5.33,=CH; 3.44,-CH_2; 1.78 & 1.64, 2 x Me. $J_{5'6'}$=8.6; $J_{6,8}$=2H_z.	122,220
7-Hydroxyflavan	Narcissus pseudo-narcissus	13	1	7.37,$H_{1'-5'}$; 6.94,H_5; 6.4, $H_{6\ \&\ 8}$; 5.05,H_2; 2.7,H_4; 2.1,H_3. $J_{5,6}$=8.5; $J_{6,8}$=4H_z.	207
4',7-Dihydroxy-flavan	Narcissus pseudo-narcissus	13	8	7.24,$H_{1',6'}$;6.83,$H_{3',5'}$; 6.35,H_8; 6.39,H_6; 6.89,H_5; 4.81,H_2; 2.8,H_4; 2.1,H_3. $J_{5,6}$=8.5; $J_{6,8}$=2.5H_z.	207
4',7-Dihydroxy-8-methylflavan	Narcissus pseudo-narcissus	13	3	7.26,$H_{1'6'}$; 6.8,$H_{3',5'}$; 6.7,H_5; 6.34,H_6; 4.95,H_2; 2.3,H_4; 2.11, Me; 2.0,H_3.	207
Broussin (4'-Methoxy-7-hydroxy-isoflavan)	Broussonetia papyrifera	29	1	4.98,dd,1H,2.12,m,2H; 2.77,m,2H,-CH_2.	208,209
Demethylvestitol (2',4',7-Trihydroxy-isoflavan)	Lotus corniculatus, Lotus hispidus, Lotus uliginosus, Tetragonolobus maritimus	12	2	7.12,$H_{6'}$; 6.87,H_8; 6.5,$H_{3'}$; 6.6,$H_{5'}$; 6.39,H_6; 6.35,H_5; 3.77,H_2; 2.5,H_3; 2.8,H_4.	79,140,142,165,210-212

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Vestitol (2',7-Dihydroxy-4'-methox isoflavan)	Medicago sativa, Lotus corniculatus, Lotus hispidus, Lotus uliginosus	12,19	1	7.3,$H_{6'}$; 6.87,H_8; 6.58,H_5; 6.5,$H_{3',5'}$; 6.41,H_6; 6.34,H_5; 3.9,OMe; 3.77,H_2; 2.47,H_3; 2.75,H_4.	165,210-212
Isovestitol (4',7-Dihydroxy-2'-methoxyisoflavan)	Tetragonolobus maritimus	12	1	7.12,$H_{6'}$; 6.8,H_8; 6.5,$H_{3',5'}$; 6.38,H_6; 6.35,H_5; 3.98,OMe; 3.77,H_2; 2.47,H_3; 2.8,H_4.	211,213
2'-Methoxyvestitol	Medicago sativa, Lotus corniculatus, Lotus hispidus	1,12,19 24	1	7.15,$H_{6'}$; 6.9,H_8; 6.45,$H_{3',5'}$; 7.38,H_6; 7.35,H_5; 3.98, 2 x OMe; 3.68,H_2; 2.45,H_3; 2.75,H_4.	165,140, 142,144, 214
5-Methoxyvestitol	Lotus hispidus	12	1	7.48,H_6; 7.15,$H_{6'}$; 6.78,H_8; 6.65,$H_{3'\&5'}$; 3.9, 2 x OMe; 3.7,H_2; 2.55,H_3; 2.75,H_4.	165,211
Lotisoflavan (2',4'-Dihydroxy-5,7-dimethoxyisoflavan)	Lotus angustis-simus, Lotus edulis	12	7	8.96, 8.78,OH; 6.86,$H_{6'}$; 6.42,$H_{3'}$; 6.27,$H_{5'}$; 6.03,$H_{6\&8}$; 4.28,H_{2eq}; 3.92,H_{2ax}; 3.75, 3.78, 2 x OMe; 3.5-3.1,H_3; 2.7,H_4.	215
Mucronulatol (2',4'-Dimethoxy-3',7-dihydroxyisolflavan)	Astragalus cicer, Astragalus gummifer, Astragalus Pyrenaicus	12		7.05,H_6; 6.88,H_6, 6.55,H_5; 6.48,$H_{5'}$; 6.48,H_8; 4.27,H_{2eq}; 4.1,H_{2ax}; 3.79, 2 x OMe; 3.67,H_2; 2.55,H_3; 2.65,H_4.	216
Astraciceran (7-Hydroxy-2'-methoxy-4',5'-methylenedioxyisoflavan)	Astragalus cicer, Astragalus Pyrenaicus	12		7.11,H_6; 6.9,$H_{6'}$; 6.45,$H_{3'}$; 6.15,H_5; 6.21,H_8; 4.3,H_{2eq}; 4.05,H_2; 3.8, OMe; 4.25, methylenedioxy; 3.5-3.3, H_3; 2.5, H_4.	216,217

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Phaseollin isoflavan (2',3,7-Trihydroxy-4',5'-methylenedioxyisoflavan)	Phaseolus vulgaris, Pisum sativum	15,30,3	1	6.91 & 6.71, $H_{5\ \&\ 6'}$; 6.57, H_8; 6.5, 6.34, $H_{6\ \&\ 5'}$; 5.59, chromoene-βH; 4.23, H_{2eq}; 3.91, H_{2ax}; 3.7-3.3, H_3; 2.89-2.8, H_4; 1.38, 2 x Me.	92,137
2'-Methoxyphaseollinisoflavan	Phaseollus vulgaris	10	1	6.9 & 6.7, $H_{5\ \&\ 6'}$; 6.56, H_8; 6.55, 6.35, $H_{6,5'}$; 5.59, chromoene-βH; 4.23, H_{2eq}; 3.91, H_{2ax}; 3.79, OMe; 3.8-3.4, H_3; 2.82, H_4; 1.38, 2 x Me.	138
2'-Methoxyphaseollidinisoflavan	Vigna unguiculata	15	1	6.91, $H_{6'}$; 6.63, H_5; 5.27, =CH; 4.3, H_{2eq}; 3.93, H_{2ax}; 2.94 & 2.81, H_4; 3.45, $-CH_2-$; 1.8, 1.74; 2 x Me; 3.73, OMe.	218
<u>COUMARINS AND CHROMONES</u>					
Asculetin	Solanum tuberosum	32-35	3	7.85, H_5; 7.75, H_8; 5.4, H_4; 5.15, H_3; 3.85, OMe.	224-229
Scopoletin	Solanum tuberosum	32-35	3	7.82, H_5; 7.75, H_8; 5.35, H_4; 5.15, H_3.	224-229
Isofraxidin-7-glucoside (7-Hydroxy-6,8-dimethoxycoumarin-7-glucoside)	Solanum tuberosum	35	3	7.95, H_5; 6.41, H_4; 5.18, H_3; 3.9, OMe; 4.04, OMe.	224
6-Hydroxymellein (3-Methyl-6,8-dihydroxy-3,4-dihydroisocoumarin)	Carrots (Daucus carota)	33,36	1	6.3, H_7; 6.21, H_5; 4.61, H_3; 2.8, H_4; 1.41, Me; 11.3, OH at C_8.	291-294

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
6-Methoxymellein	Carrots (Daucus Carota)	13,33,36	1	6.29,H_7; 6.19,H_5; 4.61,H_3: 3.75,OMe; 2.79,H_4; 1.43,Me $J_{5,7}$=2; $J_{3,Me}$=6.5H_z.	291-296
Lathodoratin (5,7-Dihydroxy-3-ethyl-chromone)	Lathyrus odoratus	3,12,13, 37-39	3	7.83,H_2; 6.24,H_6; 6.14,H_8; 2.48,-CH_2; 1.17,-Me.	96,230
STILBENES AND DIPHENYLPROPANES					
Resveratrol (Trans-3',4,5'-tri-hydroxystilbene)	Vitis vinifera	13,38	2	7.01,=CH-; 7.35,=CH-; 6.35, 6.39, 6.46-6.62, 6.65, 7.44, Ar-H. $J_{7.01,7.35}$=16H_z.	231-233
Oxyresveratrol	Morus alba	10	2	7.04,=CH; 7.4,=CH-; 6.39, 6.45-6.64, 6.7, 7.54, Ar-H $J_{7.4,7.04}$=17H_z.	234,236, 237
4'-(3-Methyl-2-butenyl)oxyresvera-trol	Morus alba	10	2	7.39,=CH-; 7.03,=CH-; 7.58,H_3; 6.8,$H_{2',6'}$; 6.47-6.67,$H_{5,6}$; 5.16,=CH-; 3.31,-CH_2-; 1.75, 1.63, 2 x Me. $J_{7.39,7.03}$=17; $J_{CH=CH_2}$=7H_z.	234
4'-(3-Methyl-1-butenyl)resveratrol	Arachis hypogaea	40	2	7.38,H_6; 7.38,H_2; 6.82,H_3; 6.82,H_5; 6.91,CH=CH; 6.82, CH=CH; 6.58,$H_{2'}$; 6.58,$H_{6'}$; 5.3,=CH; 3.36,-CH_2-; 1.78, 1.65, 2 x Me. $J_{-CH=CH}$=16; $J_{5,6}$=9; $J_{2,3}$=9; $J_{=CH-CH_2-}$=6H_z.	238,239

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
4-(3-Methylbut-1-enyl)oxyresveratrol	Arachis hypogaea	40	2	7.04,H_2; 6.89,H_6; 6.89,=CH-; 6.8,H_5; 6.76,=CH-; 6.68,=CH-; 6.68,=CH-; 6.57,$H_{2'}$; 2.41, >CH_3; 1.09, 2 x Me. $J_{=CH-CH_2-}$=6; $J_{CH=CH}$=16; $J_{5,6}$=9H_z.	238
4-(3-Methylbut-1-enyl) resveratrol	Arachis hypogaea	40	2	7.39,H_2; 7.39,H_6; 7.82,H_3; 7.82,H_5; 6.94,-CH=CH-; 6.82, -CH=CH-; 6.6,$H_{2'}$; 6.6,$H_{6'}$; 6.68, =CH-; 2.4,>CH-; 1.1, 2 X Me. J_{CH-Me}=7; $J_{-CH=CH-}$=16; $J_{5,6}$=8; $J_{2,3}$=8H_z.	238
Resveratrol Dehydrodimer (ε-Viniferin)	Vitis vinifera	13,38	2	7.4,5XOH; 6.73,=CH-; 6.93, =CH-; 7.22,(2H), 7.17,(2H), 6.86(2H), 6.76(2H), 6.75(2H), 6.35(1H), 6.27(3H), Ar-H; 5.45,>CH-O; 4.5, Ar-CH<. $J_{CH=CH}$=16; J_{Ar-H} =2.1,8.5 H_z.	232
Broussonin-A (2,4'-Dihydroxy-4-methoxydiphenyl propane)	Broussonetia papyrifera, Morus alba	10,29	2	7.01, 6.96, 6.74, 6.41, 6.34, Ar-H; 3.68,OMe; 2.59, Ar-CH_2-; 2.56, Ar-CH_2; 1.84,-CH_2-, 8.1,OH. $J_{-CH_2-CH_2}$=7.0; J_{Ar-H}=2.5 & 8H_z	240
Broussonin-B (4,2'-Dihydroxy-2-methoxydiphenyl-propane)	Brossonetia papyrifera, Morus alba	10,29	2	7.05,OH; 7.01, 6.73, 6.9, 6.34, 6.42, Ar-H; 3.75, OMe; 2.53,-CH_2-CH_2-; 1.78,-CH_2-. $J_{CH_2-CH_2}$=7; J_{Ar-H}=2.5,8H_z.	240

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^1H-NMR SHIFTS, δ	REF.
Broussonin-C (2,4, 4'-Trihydroxy-5'-isopentenyldiphenyl propane)	Broussonetia papyrifera, Morus alba	29	2	5.34, =CH-; 3.3, Ar-CH_2-CH=; 2.55, Ar-CH_2; 2.54, Ar-CH_2; 1.85, CH_2; 1.3, 2 x Me.	240
Morachalcone (2,2', 4,4'-Tetrahydroxy-3'-isopentenyl-chalchone)	Broussonetia papyrifera, Morus alba	10	2	13.97, 9.26, 9.21, 8.9, 4 x OH; 8.23, =CH; 7.72, =CH; 7.89, 7.68, 6.51, 6.52, 6.46, 5Ar-H; 5.3, =CH; 3.18, -CH_2-; 1.75 & 1.63, 2 x Me. $J_{CH=CH}$=15; $J_{=CH-CH_2}$=7; J_{Ar-H}=2 & 8H_z.	242
BENZOFURANS					
Chalcomoracin	Broussonetia papyrifera, Morus alba	10	2	12.84, OH; 9-8, 6XOH; 8.4(J9); 6.98(J8); 6.49(J2); 6.46(J9), Ar-H; 6.31, (J2,8), 7.32(J8), 6.89(J2), 6.89, 6.75, 6.74, (J2,8), Ar-H; 5.17, =CH; 3.28, -CH_2(J7); 1.71, 1.5, 2 x Me.	242
Moracin-A	Morus alba	10	2	8.62, 2 x OH; 6.94(J2), 6.82(J2,8), 6.45(J2), 6.44 (J2), 5 x Ar-H; 7.13, =CH-; 3.96, 3.88, 2 X OMe.	243
Moracin-B	Morus alba	10	2	8.5, 7.33, 2 x OH; 7.08(J0.8); 7.04, 6.97, 6.5(J2) 5 x Ar-H; 7.21, =CH; 3.94, 3.83, 2 x OMe.	243
Moracin-C	Morus alba	10	2	8.51, 8.35, 3 x OH; 7.43(J8), H_4; 7.01(J2&0.8), H_7; 6.97, $H_{2',6'}$; 6.85(J8&2), H_5; 6.95, (J0.8), H_3; 5.38, =CH-(J7);	234

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
				3.45, $-CH_2$(J7); 1.8, 1.7 2 x Me.	
Moracin-D	*Morus alba*	10	2	8.63, 2 x OH; 7.07(J0.8), H_3; 7.01(J2), H_7; 7.42(J8)H_4; 6.86(J1.6), $H_{6'}$; 6.84(J2&8), H_5; 6.82(J1.6&8), $H_{8'}$; 6.73(J0.8 &10)$H_{4'}$; 5.69(J10), $H_{3'}$; 1.42, 2 x Me.	234
Moracin-E	*Morus alba*	10	2	8.64, 2 x OH; 7.48(J8), H_4; 7.04(J2), H_5; 6.88(J0.8), H_3; 6.85(J0.8,10), $H_{4'}$; 6.86 (J2,8), H_5; 6.83(J2.4), $H_{6'}$; 6.39(J2.4,0.8), $H_{8'}$; 5.68 (J10)$H_{3'}$; 1.44, 2 x Me.	234,244
Moracin-F	*Morus alba*	10	2	8.37, 2 x OH; 7.16, H_7; 7.09, H_4; 7.01(J0.8), H_3; 6.85(J2), $H_{4',6'}$ 6.36(J2), $H_{4'}$; 3.88, 3.83, 2 x OMe.	234,244
Moracin-G	*Morus alba*	10	2	8.57, 2 x OH; 7.38(J8), H_4; 7.11, H_3; 6.95(J8), H_5; 6.94 (J2), $H_{2',6'}$; 6.43(J2), $H_{4'}$; 5.74, $H_{4''}$; 4.47, $H_{2''}$; 3.74, $H_{5''}$; 1.58, Me.	234,244
Moracin-H	*Morus alba*	10	2	8.51, 2 x OH, 7.5, H_5; 6.93 (J2), $H_{2',6'}$; 6.51, H_3; 6.41 (J2), $H_{4'}$; 5.75, $H_{4''}$; 4.48, $H_{2''}$; 3.92, OMe; 3.67, $H_{5''}$; 1.6, Me.	234,244

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Vignafuran [2-(2'-Methoxy-4'-hydroxy-phenyl)-6-methoxy-benzofuran]	Vigna unguiculata	15	1	7.85,(J9.3),$H_{6'}$; 7.5(J9),H_4; 7.05,$H_{3,7}$; 6.85(J2.7&9),H_5; 6.55,$H_{3',5'}$; 3.9, OMe, 3.85, OMe.	265-271
6-Demethylvignafuran	Tetragonolobus maritimus	12	1	7.8(J9),$H_{6'}$; 7.48(J9),H_4; 6.9,$H_{3,7}$; 6.8(J2.2&9),H_5; 6.5,$H_{3',5'}$; 3.9, OMe.	265,213
ACETYLENS AND FURANOACETYLEINS					
Wyerone	Vicia fabae, Vicia narbonesis, Vicia galilea	13,19	4	7.43,$H_{1'}$; 7.3,H_β; 6.78,$H_{\beta'}$; 6.6,$H_{2'}$, 6.4,H_5; 5.71,H_4; 3.78, OMe; 2.56,H_6; 1.25,H_7.	245,246
Wyerone acid	Vicia fabae, Jack bean (canavalia ensiformis)	13,26,20	1	11.2,-COOH; 7.4,$H_{1'}$; 7.28,H_β; 6.78,$H_{\beta'}$; 6.58,$H_{2'}$; 6.4,H_5; 5.7,H_4; 2.5,H_6; 1.2,H_7.	247-254, 150
Wyerone epoxide	Vicia fabae	13,26	1	7.48,$H_{1'}$; 6.37,(J3.7),H_β; 6.75(J3.7),$H_{\beta'}$; 6.4(J16),$H_{2'}$; 3.83, OMe; 3.66(J6.1), H_4; 3.21(J3.9&6),H_5; 1.76,H_6; 1.15(J7.5),H_7.	254-256
Wyerol epoxide	Vicia fabae	26	1	6.4,$H_{\beta'}$; 6.53,H_β; 5.53,H_1; 3.54,H_6; 3.09,H_5.	254
4,5-Dihydro-4,5-dihydroxywyerol	Vicia fabae	26	1	6.53,H_β; 6.4,$H_{\beta'}$; 5.53,H_1; 3.65,H_5; 4.3,H_4.	254
Falcarindiol (Heptadeca-1,9-diene-4,6-diyne-3,8-diol)	Lycopersicon esculentum, phaseolus vulgaris, Daucus carota, Aegopodium Podagraria	42	4	5.9(J5,9,17),H_{1-13}; 5.7-4.8, H_{8-10}; 2.11,$H_{11,12}$; 1.3, H_{13-16}; 0.90, Me.	257-261

COMPOUND	PLANT SOURCE	STRESS AGENT	SOLVENT	^{1}H-NMR SHIFTS, δ	REF.
Falcarinol (Hepta-deca-1,9-diene-4,6-diyne-3-ol)	Lycopersicon esculentum, phaseolus vulgaris, Daucus carota, Aegopodium Podagraria	42	4	5.3,H_1; 5.95(J4.5,9,16),H_2; 5.45,$H_{9,10}$; 4.8(J4.5),H_3; 2.1,H_{11}; 3.0(J5),H_8; 1.3, H_{12-16}; 0.90, Me .	257-261
Tetradeca-6-ene-1,3-diyne-5,8-diol	Lycopersicon esculentum		1	5.63,$H_{6,7}$; 5.3,H_5; 4.5,H_8; 2.85, 2 X OH; 2.2,H_1; 1.5,H_9; 1.3,H_{8-13}: 0.90, Me.	260
Safynol (3,11-Tri-decadiene-5,7,9-triyne-1,2-diol)	Carthamus tinctorius	25,29	1	5.5,$H_{3,12}$; 4.7,$H_{2,4,11}$; 3.7, H_1; 1.8, Me .	262-264
Dehydrosafynol (11-Tridecene-3,5,7,9-tetrayne-1,2-diol)	Carthamus tinctorius	29	1	5.45,H_{12}; 4.7,$H_{2,11}$; 3.75,H_1; 1.5, Me.	262-264
Gossypol	Gossypium hirsutum, Gossypium barbadense	24, 19	1	15.2, 2 X OH; 11.3,CHO; 7.8, 2 X Ar-H; 6.4, 2 X OH; 5.9, 2 X OH; 3.75, >CH-; 2.2, 2 X Ar-Me; 1.55, 4 X Me.	272-281
Hemigossypol	Gossypium hirsutum	24	1	7.3,-CHO; 6.5, Ar-H; 5.8, Ar-H; 3.7,>CH; 3.5,OH; 2.4, Ar-Me; 1.45, 2 X Me.	282,283
Vergosin (Deoxy-6-methoxyhemigossypol)	Gossypium hirsutum	24,11	1	7.28,CHO; 6.54, Ar-H; 5.75 Ar-H; 3.9, OMe; 3.65,>CH-; 3.5,OH; 2.3, Ar-Me; 1.45, 2 X Me.	282,283

REFERENCES

1. M. Afzal and Galib Al-Oriquat, Heterocycles, 1982, 19, 1295.
2. I.A.M. Cruickshank, Ann. Rev. Phytopathol., 1963, 1, 351.
3. J.L. Ingham, Bot. Rev., 1972, 38, 343.
4. J. Kuc, Ann. Rev. Phytopathol., 1972, 10, 207.
5. J.A. Bailey and J.L. Ingham, Physiol. Plant Pathol., 1971, 1, 451.
6. W.L. Klarman and F. Hammerschlag, Phytopathology, 1972, 62, 719.
7. P. Stholasuta, J.A. Bailey, V. Severin and B.J. Deverall, Plant Physiol., 1971, 1, 177.
8. N.T. Keen and B.W. Kennedy, Physiol. Plant Pathol., 1974, 4, 173.
9. J.E. Cross, B.W. Kennedy, J.W. Lambert and R.L. Cooper, Plant Disease Reports, 1960, 50, 557.
10. C. Leben, G.C. Daft and A.F. Schmitt, Phytopathology, 1968, 58, 1143.
11. A.A. Bell, Phytopathology, 1967, 57, 759.
12. B.A. Cunningham, Scientific American, 1977, 237, 96.
13. E. Chalutz and M.A. Stahman, Phytopathology, 1969, 59, 1972.
14. K.O. Muller, Phytopathology, 1956, 27, 237.
15. P. Langcake, D. Cartwright, D.P. Leworthy, R.J. Pryce and J.P. Ride, Neth. J. Plant Pathol., 1978, 83, 153.
16. K. Muller and G. Gerisch, Nature, 1978, 274, 445.
17. D.R. Perrin and I.A.M. Cruickshank, Aust. J. Sci., 1965, 18, 803.
18. J.A. Bailey and M. Berthrer, Phytochemistry, 1981, 20, 188.
19. J.E. Rahe and R.M. Arnold, Can. J. Bot., 1975, 53, 921.
20. B.C. Carton, C.E. Peterson and N.E. Tolbert, Plant Physiol., 1961, 36, 550.
21. M. Reuveni and Y. Cohen, Physiol. Plant Pathol., 1978, 12, 179.
22. R.A. Dixon and D.S. Bendall, Physiol. Plant Pathol., 1978, 13, 283.
23. J.A. Hargreaves and J.A. Bailey, Physiol. Plant Pathol., 1978, 13, 89.
24. F. Koch, M. Baur, M. Burda and E.F. Elstner, Phytopathology, 1980, 98, 40.
25. H.D. Van Etten, Phytochemistry, 1976, 15, 655.
26. R.O. Braz Filho, O.R. Gottlieb, S.L. Vieira Pinho, F.J. Queiroz Monte and A.I. Da Rocha, Phytochemistry, 1973, 12, 1184.
27. P. Mantalhini and E.F. Elstner, Planta, 1977, 135, 301.
28. J.W.D.M. Henfling, N. Lisker and J. Kuc, Phytopathology, 1978, 68, 857.
29. I. Uritani, M. Uritani and H. Yamada, Phytopathology, 1960, 50, 30.

30. I. Paradies, B. Humme, H.H. Hoppe, R. Heitefuss and E.F. Elstner, Planta, 1979, 146, 193.

31. J.A. Bailey, Ann. Appl. Biol., 1969, 64, 315.

32. L.A. Hadwiger and M.E. Schwochau, Plant Physiol., 1971, 47, 346.

33. L.A. Hadwiger, A. Tafri, A. Von Broembson and R. Eddy, Plant Physiol., 1974, 53, 52.

34. P.J.G.M. Dewit and P.H.M. Roseboam, Physiol. Plant Pathol., 1980, 16, 391.

35. J.M. Dow and J.A. Callow, Physiol. Plant Pathol., 1979, 15, 27.

36. N.T. Keen and M. Legrand, Physiol. Plant Pathol., 1980, 17, 175.

37. N.T. Keen, "Biochemistry and Cytology of Plant Parasite Interaction", Ed. K. Tomiyama, Academic Press, 1976, p. 84.

38. E.A. Clark, P. Gleeson, S. Harrison and R.B. Knox, Proced. National Acad. Sci., U.S.A., 1979, 76, 3358.

39. N.T. Keen, Physiol. Plant Pathol., 1971, 1, 265.

40. R.G. Brown and W.C. Kimnins, Inter. Rev. Biochem., 1977, 13, 183.

41. A.J. Anderson, Phytopathology, 1979, 69, 913.

42. J. Kuc, W.W. Carrier and M.J. Shih, Terpenoid Phytoalexine, "Biochemical Aspects of Plant Parasite Relationships", Ed. J. Friend and D.R. Threfall, Academic Press, London, 1970, p. 225.

43. N.T. Keen and M. Long, Physiol. Plant Pathol., 1972, 2, 307.

44. O. Bedwin, Proc. Royal Soc. London, 1979, 205, 271.

45. L.A. Hadwiger and M.E. Schwochau, Biochem. Biophys. Research Commun., 1970, 38, 683.

46. R.A. Dixon and K.W. Fuller, Physiol. Plant Pathol., 1977, 11, 287.

47. M. Wade and P. Albersheim, Proc. Natl. Acad. Sci., U.S.A. 1979, 76, 4433.

48. A.A. Bell and J.T. Presley, Phytopathology, 1969, 59, 1147.

49. I.A.M. Cruickshank and D.R. Perrin, Life Science, 1969, 7, 449.

50. A.I. Zaki, N.T. Keen and D.C. Erwin, Phytopathology, 1972, 62, 1402.

51. J.A. Bailey, Phytochemistry, 1969, 8, 1393.

52. P. Moesta and H. Grisebach, Arch. Biochem. Biophys., 1981, 211, 39.

53. M.C. Hahn, A.G. Darvill and A. Albershein, Plant Physiol., 1981, 68, 1161.

54. O. Kazuko, Nippon Nogei Kagaku Kaishi, 1981, 55, 1009.

55. M.C. Hahn, Diss. Abstr. Ins. B., 1981, 42, 1253.

56. J.C. Lamb, M.A. Lawton, S.J. Taylor and R.A. Dixon, Ann. Phytopathol., 1980, 12, 423.

57. I.M. Whitehead, P.M. Fey and R.A. Dixoni, Planta, 1982, 154, 156.

58. M. Moesta and H. Grisebach, Physiol. Plant Pathol., 1982, 21, 65.

59. T.M. O'Neill and T.W. Mansfield, Physiol. Plant Pathol., 1982, 20, 243.

60. P. Moesta and H. Grisebach, Nature, 1980, 286, 710.

61. T. Tomiyama, T. Sakuma, N. Ishizaka, N. Sato, N. Katsui, M. Takasugi and T. Masamune, Phytopathology, 1968, 58, 115.

62. J.A. Bailey, Physiol. Plant Pathol., 1974, 4, 477.

63. J.A. Bailey and B.J. Dervall, Physiol. Plant Pathol., 1971, 1, 435.

64. J.L. Varns, J. Kuc and E. Williams, Phytopathology, 1971, 61, 174.

65. L.J. Duczek and V.J. Higgins, Can. J. Bot., 1976, 54, 2609.

66. M. Yoshikawa, K. Yamahachi and H. Masago, Physiol. Plant Pathol., 1978, 12, 73.

67. N. Sato and K. Tomiyama, Ann. Phytopathol. Soc. Japan, 1969, 35, 202.

68. J.A. Bailey and J.L. Ingham, Physiol. Plant Pathology, 1971, 1, 451.

69. A.E. Arinze and I.M. Smith, Physiol. Plant Pathology, 1980, 17, 145.

70. K.G.R. Pachler and W.G.E. Underwood, Tetrahedron, 1967, 23, 1817.

71. H. Suginome and T. Iwadore, Experientia, 1962, XIII, 163.

72. R.S. Chan, C.K. Ingold and V. Prelog, Experientia, 1956, XII, 81.

73. J.B. Bredenberg and P.K. Hietala, Acta Chem. Scand., 1961, 15, 696 & 936.

74. Y. Fujise, T. Toda and S. Ito, Chem. Pharma. Bull., 1965, 13, 93.

75. S. Ito, Y. Fujise and A. Mori, Chem. Commun., 1965, 595.

76. A. MeGookin, A. Robertson and W.B. Whalley, J. Chem. Soc., 1940, 787.

77. A. Pelter and P.I. Amenechi, J. Chem. Soc.(C)., 1969, 887.

78. D.R. Perrin and C.P. Whittle, Tetrahedron Letters, 1972, 17, 1676.

79. D.G. Smith, A.G. McInnes, V.J. Higgins and R.L. Miller, Physiol. Plant Pathol., 1971, 1, 41.

80. H. Suginome, Bull. Chem. Soc. Japan, 1966, 39, 1544, 1535.

81. V.J. Higgins and D.G. Smith, Phytopathology, 1972, 62, 235.

82. H. Suginome, Experientia, 1962, 18, 161.

83. W. Cocker, T. Dahl, C. Dempsey and T.B.H. McMurry, J. Chem. Soc., 1962, 4906.

84. S. Shibata and Y. Nishikawa, Chem. Pharm. Bull. (Tokyo), 1963, 11, 167.

85. S.H. Harper, A.D. Kemp, W.G.E. Underwood and R.V.M. Campbell, J. Chem. Soc., 1969, 1109.

86. J.L. Duczek and V.J. Higgins, Can. J. Bot., 1976, 54, 2620.

87. J.L. Ingham and J.B. Harborn, Nature, 1976, 260, 241.

88. V.J. Higgins, Physiol. Biochem., 1978, 68, 339.

89. V.J. Higgins, Physiol. Biochem., 1975, 6, 5.

90. H.D. Van Etten and D.A. Smith, Physiol. Plant Pathol., 1975, 5, 225.

91. H.D. Van Etten, S.G. Pueppke and T.C. Kelsey, Phytochemistry, 1975, 14, 1103.

92. A. Fuchs, F.W. de Varies, C.A. Landbeer and A. Van Veldhuizen, Phytochemistry, 1980, 19, 917.

93. A. Stoessl, Can. J. Biochem., 1972, 50, 107.

94. N.J. Bilton, J.R. Debnam and I.M. Smith, Phytochemistry, 1976, 15, 1411.

95. D.R. Perrin and W. Bottomly, Nature, 1961, 191, 76.

96. D.J. Robeson, J.L. Ingham and J.B. Harborne, Phytochemistry, 1980, 19, 2171.

97. D.R. Perrin and D.R. Perrin, J. Am. Chem. Soc., 1962, 84, 1919, 1922.

98. I.A.M. Cruickshank, Aust. J. Biol. Sci., 1962, 15, 147.

99. I.A.M. Cruickshank and D.R. Perrin, Aust. J. Biol. Sci., 1961, 14, 336.

100. I.A.M. Cruickshank and D.R. Perrin, Nature, 1960, 187, 799.

101. M.E. Schwochu and L.E. Hadwiger, Arch. Biochem. Biophys., 1968, 126, 731.

102. I.A.M. Cruickshank and D.R. Perrin, Aust. J. Biol. Sci., 1965, 18, 817, 829.

103. K. Uehara, Hiroshima Agr. Cell., 1963, 2, 41.

104. J.A. Bailey and R.A. Skipp, Ann. Appl. Biol., 1978, 89, 354.

105. J. Eisenbiess and H. Schmid, Helv. Chim. Acta, 1959, 42, 61.

106. S.G. Pueppke and H.D. Van Etten, Phytopathology, 1974, 64, 1433.

107. F.J. Muehlbauer and C. Sander, Pism Newsletter, 1975, 7, 32.

108. R.A. Nilan, E.G. Sideris, A. Kleinhofs, C. Sander and C.F. Konzak, Mutation Research, 1973, 17, 142.

109. L.A. Hadwiger, C. Sander, J. Eddyrean and J. Ralston, Phytopathology, 1976, 66, 629.

110. H.D. Van Etten, Phytopathology, 1973, 63, 1477.

111. E.M. Bickoff, R.L. Lyman, A.L. Livingstone and A.N. Booth, J. Amer. Chem. Soc., 1958, 80, 3969.

112. P.C. Duttagupta, H.N. Khastgir and P. Sengupta, Chem. & Ind., 1960, 937.

113. T.R. Govindachari, K. Nagarajan and B.R. Pai, J. Chem. Soc., 1956, 629.

114. T. Shiraishi, H. Oku, M. Isono and S. Ouchi, Plant and Cell Physiol., 1975, 16, 939.

115. J.B. Bredenberg and J.N. Shoolery, Tetrahedron Letters, 1961, 9, 285.

116. D.J. Robeson, Phytochemistry, 1978, 17, 807.

117. D.J. Robeson and J.L. Ingham, Phytochemistry, 1979, 18, 1715.

118. J.T. Cook, W.D. Ollis, I.O. Sutherland and O.R. Gottlieb, Phytochemistry, 1978, 17, 1417.

119. H.G. Krishnamurthy and J.S. Prasad, Phytochemistry, 1980, 19, 2797.

120. J.L. Ingham, Z. Naturforsch Teil C., 1979, 34, 683.

121. J.A. Brink, G.J.H. Rall and J.P. Englelbrecht, Phytochemistry, 1975, 13, 1581.

122. M.E. Oberholzer, G.J.H. Rall and D.G. Roux, Phytochemistry, 1976, 15, 1283.

123. B.S. Joshi and N.V. Kamat, J. Chem. Soc. Perkin I, 1973, 907.

124. I.M. Smith, Ann. Appl. Biol., 1978, 89, 325.

125. P.J. Kuhn and D.A. Smith, Proc. Assoc. Appl. Biolog., 1975, 362.

126. I.A.M. Cruickshank and D.R. Perrin, Life Sciences, 1968, 7, 449.

127. A.J. Morris and D.A. Smith, Ann. Appl. Biol., 1978, 89, 344.

128. M.D. Woodward, Phytochemistry, 1980, 19, 921.

129. F.G. Arenal, A. Fraile and E.M. Sagsta, Physiol. Plant Pathol., 1978, 13, 151.

130. D.R. Perrin and C.P. Whittle, Tetrahedron Letters, 1972, 1673.

131. R.A. Shipp and J.A. Bailey, Physiol. Plant Pathol., 1976, 9, 253.

132. J.E. Rahe, Can. J. Bot., 1973, 51, 2423.

133. D.R. Perrin, Tetrahedron Letters, 1964, 29.

134. I.A.M. Cruickshank and D.R. Perrin, Phytopathol. Z., 1971, 70, 209.

135. J. Van Den Heuvel, H.D. Van Etten, J.W. Serum, D.L. Coffen and T.H. Williams, Phytochemistry, 1974, 13, 1129.

136. J.A. Bailey, J. Gen. Microbiol., 1973, 25, 119.

137. J.L. Ingham, Z. Naturforsch. Teil C., 1979, 34, 293.

138. J.L. Ingham, Z. Naturforsch. Teil C., 1977, 32, 449.

139. J.L. Ingham, Biochem. Syst. Ecol., 1978, 6, 217.

140. P.M. Dewick and M. Martin, Phytochemistry, 1979, 18, 597.

141. P.M. Dewick, Phytochemistry, 1977, 16, 93.

142. P.M. Dewick and M. Martin, Phytochemistry, 1979, 18, 591.

143. P.M. Dewick, Phytochemistry, 1975, 14, 979.

144. J.L. Ingham and R.L. Miller, Nature, 1973, 242, 125.

145. J.A. Hargreaves, Proc. Assoc. Appl. Biolog., 1978, 89, 339.

146. S.H. Harper, A.D. Kemp and W.G.E. Underwood, Chem. & Ind., 1965, 562.

147. W. Cocker, T.B.H. MeMurry and P.A. Staniland, J. Chem. Soc., 1965, 1034.

148. I.A.M. Cruickshank, J. Veeraraghavan and D.R. Perrin, Aust. J. Plant Physiol., 1974, 1, 149.

149. F.J. Khan and J.M. Milton, Physiol. Plant Pathol., 1978, 13, 215.

150. N.T. Keen, Phytopathology, 1972, 62, 1365.

151. D.L. Gustine, R.T. Sherwood and C.P. Vance, Plant Physiol., 1972, 61, 226.

152. L.J. Duczek and V.J. Higgins, Can. J. Bot., 1976, 54, 2620.

153. V.J. Higgins, Physiol. Plant Pathol., 1972, 62, 289.

154. J.L. Ingham and K.R. Markham, Phytochemistry, 1980, 19, 1203.

155. J.L. Ingham, Z. Naturforsch. Teil C., 1980, 35. 384.

156. J.L. Ingham, Phytochemistry, 1976, 15, 1489.

157. J.N. Bilton, J.R. Debnam and I.M. Smith, Phytochemistry, 1976, 15, 1411.

158. N.W. Preston, Phytochemistry, 1977, 16, 2044.

159. R.L. Lyne and L.J. Mulheirn, Tetrahedron Letters, 1978, 3127.

160. D.M.X. Donnelly and M.A. Fitzgerald, Phytochemistry, 1971, 10, 3147.

161. A.A. Craveiro and O.R. Gottlieb, Phytochemistry, 1974, 13, 1629.

162. K. Kurosawa, W.D. Ollis, B.T. Redman, I.O. Sutherland and O.R. Gottlieb, Phytochemistry, 1978, 17, 1413.

163. S.G. Pueppke and H.D. Van Etten, J. Chem. Soc. Perkin I, 1975, 946.

164. V.K. Kalra, A.S. Kukla and T.R. Seshadri, Indian J. Chem., 1967, 5, 605.

165. J.L. Ingham and P.M. Dewick, Phytochemistry, 1979, 18, 1711.

166. J.F. Lampard, Phytochemistry, 1974, 13, 291.

167. N.T. Keen, A.T. Zaki and J.J. Sims, Phytochemistry, 1972, 11, 1031.

168. J.U. Zahringer, L.J. Mulheirn, R.L. Lyne and H. Grisebarch, FEBS Letters, 1979, 101, 90.

169. W.L. Klarman and J.B. Sanford, Life Science, 1968, 7, 1095.

170. N.T. Keen, J.J. Sims, D.C. Erwin, E. Rice and J.E. Partridge, Phytopathology, 1971, 61, 1084.

171. N.T. Keen, Phytopathology, 1978, 68, 1237.

172. R.S. Burden and J.A. Bailey, Phytochemistry, 1975, 14, 1389.

173. R.L. Lyne, L.J. Mulheirn and D.P. Leworthy, Chem. Commun., 1976, 497.

174. R.L. Lyne and L.J. Mulheirn, Tetrahedron Letters, 1978, 3127.

175. M. Yoshikawa, Nature, 1978, 275, 546.

176. J.J. Sims, N.T. Keen and K.K. Honwad, Phytochemistry, 1972, 11, 827.

177. E.M. Bickhoff, R.L. Lyman, A.L. Livingstone and A.N. Booth, J. Amer. Chem. Soc., 1958, 80, 3969.

178. P.M. Dewick, W. Borzand and H. Grieshach, Phytochemistry, 1970, 9, 775.

179. D.R. Biggs and G.J. Shaw, Phytochemistry, 1980, 15, 2801.

180. E.M. Bickhoff, R.R. Spencer, S.C. Witt and B.E. Kuckles "Studies on the chemical and biological properties of coumesterol and related compounds", Technical Bulletin, 1408, U.S. Dept. of Agriculture, 1969.

181. A.L. Livingstone, E.M. Bickhoff, R.E. Lundin and L. Jurd, Tetrahedron, 1964, 20, 1963.

182. E. Wong and G.C.M. Latch, Phytochemistry, 1971, 10, 466.

183. J.J. Sims, N.T. Keen and K.K. Honwad, Phytochemistry, 1972, 11, 827.

184. J. Van den Heuvel and J.A. Glazener, Neth. J. Plant Pathol., 1975, 81, 125.

185. J.J. Rilly and W.L. Klarman, Phytopathology, 1972, 62, 1113.

186. R.S. Burden, J.A. Bailey and G.G. Vincent, Phytochemistry, 1974, 13, 1789.

187. R.S. Robeson and J.L. Ingham, Phytochemistry, 1979, 18, 1715.

188. N.T. Keen and J.D. Paxton, Phytopathology, 1975, 65, 635.

189. F. Nonaka, S. Isayama and H. Furukawa, Agr. Bull. Saga Univer., 1966, 22, 51.

190. L. Farkas, A. Gottsegen, M. Nogradi and S. Antus, J. Chem. Soc. C, 1971, 1994.

191. D.R. Biggs, Aust. J. Chem., 1975, 28, 1389.

192. J.L. Ingham, Naturforsch. Z., 1976, 31C, 504.

193. J.P. Siva and R.S. Varma, Phytochemistry, 1977, 16, 1120.

194. J.L. Ingham, N.T. Keen and T. Hymowitz, Phytochemistry, 1977, 16, 1943.

195. J.L. Ingham, Naturforsch. Z., 1977, 32C, 1018.

196. J.A. Morris and D.A. Smith, Ann. Appl. Biol., 1978, 89, 344.

197. J.E. Partridge and N.T. Keen, Phytopathology, 1976, 66, 426.

198. D.A. Smith, H.D. Van Etten and O.F. Bateman, Physiol. Plant Pathol., 1975, 5, 51.

199. D.A. Smith, Physiol. Plant Pathol., 1976, 9, 45.

200. D.A. Smith, H.D. Van Etten, J.D. Serum, T.M. Jones, D.F. Bateman, T.H. William and O.L. Coffen, Physiol. Plant Pathol., 1973, 13, 293.

201. P.J. Kuhn and D.A. Smith, Proc. Amer. Phytopathol. Soc., 1976, 3, 261.

202. P.J. Kuhn and D.A. Smith, Proc. Assoc. Appl. Biol., 1978, 89, 362.

203. P.J. Kuhn and D.A. Smith, Physiol. Plant Pathol., 1979, 14, 179.

204. W. Barz, R. Schlepphorst and J. Laimer, Phytochemistry, 1976, 15, 87.

205. F. Gargia, A. Fraile and E.M. Sagasta, Physiol. Plant Pathol., 1978, 13, 151.

206. R.S. Burden, J.A. Bailey and G.W. Dawson, Tetrahedron Letters, 1972. 4175.

207. D.T. Coxon, T.M. O'Neill, J.W. Mansfield and A.E.A. Porter, Phytochemistry, 1980, 19 , 889.

208. K. Freudenberg, J.H. Stocker and J. Porter, Chem. Ber., 1957, 90, 957.

209. M. Takasugi, Y. Kumagai, S. Nagao, T. Masamune, A. Shirata and K. Takahashi, Chem. Lett., 1980, 1459.

210. M.R. Bonde, R.L. Miller and J.L. Ingham, Phytochemistry, 1973, 12, 2957.

211. J.L. Ingham, Phytochemistry, 1977, 16, 1279.

212. J.L. Ingham and R.L. Miller, Nature, 1973, 242, 241.

213. J.L. Ingham and P.M. Dewick, Phytochemistry, 1978, 17, 535.

214. K. Kurosawa, W.D. Ollis, I.O. Sutherland and O.R. Gottleib, Phytochemistry, 1978, 17, 1417.

215. J.L. Ingham and P.M. Dewick, Phytochemistry, 1980, 19, 2799.

216. J.L. Ingham and P.M. Dewick, Phytochemistry, 1980, 19, 1767.

217. F.R. Van Heerden, E.V. Brandt and D.G. Roux, J. Chem. Soc. Perkin I, 1978, 137.

218. W.W. Preston, Phytochemistry, 1975, 14, 1131.

219. J.L. Ingham, Phytochemistry, 1978, 17, 165.

220. M.D. Underwood, Phytochemistry, 1979, 18, 363.

221. H.D. Van Etten, Phytochemistry, 1973, 12, 1791.

222. S.S. Patil and S.S. Ganamanickam, Nature, 1976, 259, 486.

223. S.S. Patil, A. Rev. Phytopathol., 1974, 12, 259.

224. A.G. Malmberg and O. Theander, Phytochemistry, 1980, 19, 1739.

225. J.C. Hughes and T. Swam; Phytopathology, 1960, 50, 398.

226. D.J. Austin and D.D. Clarke, Nature, 1966, 210, 1165.

227. F. Holm and F.M. Lashin, Biotechnical Institute Kolding, Denmark, 1977, 1-10.

228. T. Minamikawa, T. Akazawa and I. Uritani, Nature, 1962, 195, 726.

229. T. Minamikawa, T. Akazawa and I. Uritani, Agri. Biol. Chem., 1964, 28, 230.

230. V.J. Higgins and R.L. Miller, Phytopathology, 1968, 58, 1377.

231. P. Langcake and R.J. Pryce, Experientia, 1977, 33, 151.

232. P. Langcake and R.J. Pryce, Physiol. Plant Pathol., 1976, 9, 77.

233. J.L. Ingham, Phytochemistry, 1976, 15, 1791.

234. M. Takasugi, L. Munoz, T. Masamune, A. Shirata and K. Takahashii, Chem. Lett., 1978, 1239.

235. M. Takaoka, Nippon Kagaku Kaishi, 1939, 60, 1261.

236. R.A. Barnes and N.N. Gerbes, J. Amer. Chem. Soc., 1955, 77, 3259.

237. V.H. Deshpande, R. Srinirasan and A.V. Rama Rao, Indian J. Chem., 1975, 13, 453.

238. G.E. Aquamah, P. Langcake, D.P. Leworthy, J.A. Page, R.J. Pryce and R.N. Strange, Phytochemistry, 1981, 20, 1381.

239. N.T. Keen and J.L. Ingham, Phytochemistry, 1976, 15, 1794.

240. M. Takasugi, M. Aneta, T. Masamune, A. Shirata and K. Takahashi, Chem. Lett., 1980, 339.

241. J.B. Harborn, J.L. Ingham, L. King and H. Payne, Phytochemistry, 1976, 15, 1485.

242. M. Takasugi, S. Nagao, T. Masamune, A. Shirata and K. Takahashi, Chem. Lett., 1980, 1573.

243. M. Takasugi, S. Nagao and T. Masamune, Tetrahedron Letters, 1978, 797.

244. M. Takasugi, S. Nagao and T. Masamune, Tetrahedron Letters, 1979, 4675.

245. C.H. Fawcett, D.M. Spencer, R.L. Wain, A.G. Fallis, E.R.H. Janes, M. Le Quan, C.B. Page, V. Thaller, D.C. Schubrook and P.M. Whitman, J. Chem. Soc. C, 1968, 2455.

246. R.O. Cain and A.E.A. Porter, Phytochemistry, 1979, 18, 322.

247. J.W. Mansfield and B.J. Deverall, Ann. Appl. Biol., 1974, 77, 227.

248. B.J. Deverall and J.C. Vessey, Ann. Appl. Biol., 1969, 63, 449.

249. R.M. Letcher, D.A. Widdowson, B.J. Deverall and J.W. Mansfield, Phytochemistry, 1970, 9, 249.

250. M.S. Kemp, Phytochemistry, 1978, 17, 1002.

251. J.W. Mansfield, A.E.A. Porter and R.V. Smallman, Phytochemistry, 1980, 19, 1057.

252. J.A. Hargreaves, J.W. Mansfield and S. Rossall, Physiol. Plant Pathol., 1977, 11, 227.

253. J.A. Hargreaves, J.W. Mansfield and D.T. Coxon, Phytochemistry, 1976, 15, 651.

254. J.A. Hargreaves, J.W. Mansfield, D.T. Coxon and J.R. Price, Phytochemistry, 1976, 15, 1119.

255. J.W. Mansfield, Nature, 1974, 252, 316.

256. A. Stoessl, Phytopathology, 1977, 67, 64.

257. R.K. Bentley, D. Bhattacharjee, R.H.J. Sir Ewart and V. Thaller, J. Chem. Soc. C, 1969, 685.

258. F. Bohlmann, U. Niedhalla and K.M. Rode, Chem. Ber., 1966, 99, 3552.

259. B. Garrod, B.G. Lewis and D.T. Coxon, Physiol. Plant Pathol., 1978, 13, 241.

260. P.J.M. De Wit and E. Kodde, Physiol. Plant Pathol., 1981, 18, 143.

261. K.E. Schutte and G. Nulfhorst, Archiv. Der. Pharmacie, 1977, 310, 285.

262. E.H. Allen and C.A. Thomas, Phytopathology, 1971, 61, 1107.

263. E.H. Allen and C.A. Thomas, Phytochemistry, 1971, 10, 1579.

264. F. Bohlmann, S. Postulka and J. Ruhnke, Chem. Ber., 1958, 91, 1646.

265. N.W. Preston, K. Chamberlain and A.A. Skipp, Phytochemistry, 1975, 14, 1843.

266. R. Royer, P. Demerseman and R. Cavier, German Patent, 1972, No. 2131927.

267. R. Royer, L. Rene, R. Cavier and P. Barlier, German Patent, 1971, No. 2131489.

268. F. Pan and T.C. Wang, J. Chinese Chem. Soc. (Taiwan), 1962, 8, 374.

269. F. Pan and G.A. Wiese, J. Amer. Pharm. Association, 1960, 49, 259.

270. L. Jurd and A.D. King, U.S. Patent, 1974, No. 3, 810, 990.

271. G.A. Carter, K. Chamberlain and R.L. Wain, Ann. Appl. Biol., 1978, 88, 57.

272. V.L. Frampton, J.D. Edwards and H.R. Henze, J. Amer. Chem. Soc., 1948, 70, 3844.

273. R.T. O'Connor, P.R. Der Haar, E.F. Dupre, L.E. Brown and C.H. Pominski, J. Amer. Chem. Soc., 1954, 76, 2368.

274. P.F. Heinstein, F.H. Smith and S.B. Tove, J. Biol. Chem., 1962, 237, 2643.

275. R. Adams, T.A. Geissmann and J.D. Edwards, Chem. Rev., 1960, 60, 555.

276. C.H. Boatner, "Cottonseed" Ed. A.E. Bailey, Interscience Publishers, N.Y. 1948, p. 213.

277. W.A. Withers and F.E. Carruth, J. Agr. Res., 1915, 5, 261.

278. E. Eagle, J. Amer. Oil Chemist, 1960, 37, 40.

279. G.T. Bottger, E.T. Sheehan and M.J. Lukefahr, J. Econ. Entomol., 1964, 57, 283.

280. M.D. Lukefahr and D.F. Martin, J. Econ. Entomol., 1966, 59, 176.

281. D. Davis, Phytopathology, 1964, 54, 290.

282. A.I. Zaki, N.T. Keen and D.C. Erwin, Phytopathology, 1972, 62, 1402.

283. A.I. Zaki, N.T. Keen and D.C. Erwin, Phytopathology, 1972, 62, 1398.

284. R.E. Hunter, J.M. Hallom, J.A. Veech and W.W. Carter, Physiol. & Biochem., 1978, 68, 347.

285. J.A. Veech and M.A. McClure, J. Nematology, 1977, 9, 225.

286. J.A. Bailey, J. Gen. Microbiology, 1970, 61, 409.

287. M.D. Woodward, Phytochemistry, 1980, 19, 921.

288. D.J. Robeson and J.B. Harborne, Phytochemistry, 1980, 19, 2359.

289. J.L. Ingham, N.T. Keen, K.R. Markham and L.J. Mulheir, Phytochemistry, 1981, 20 807.

290. N.T. Keen and L.J. Littlefield, Proc. Am. Pathol. Soc., 1977, 4, 101.

291. E. Chalutz, J.E. Devay and E.C. Maxie, Plant Physiol., 1969, 44, 235.

292. D.T. Coxon, R.F. Curtis, R.R. Price and G. Levett, Phytochemistry, 1973, 12, 1881.

293. J.G. Jaworski and J. Kuc, Plant Physiol., 1974, 53, 331.

294. V.K. Harding and J.B. Heale, Physiol. Plant Pathol., 1980, 17, 227.

295. R.E. Hampton, Phytopathology, 1962, 52, 413.

296. B.A. Hemdon, J. Kuc and E.B. Williams, Phytopathology, 1966, 56, 187.

297. D.H. Daniels and L.A. Hadwiger, Physiol. Plant Pathol., 1976, 8, 9.

298. H. Oku, S. Ouchi, T. Shiraishi, K. Utsumi and S. Jeno, Proc. Japan Acad. Sci., 1976, 52, 33.

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