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# ANALYTICAL TECHNIQUES FOR THE CHARACTERIZATION OF FLAVONOIDS-A REVIEW

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Standard methods of extraction, separation and chemical characterization of flavonoid compounds are described by Tracey[1] as well as Harborne[2]. Systematic procedure for the flavonoid identification employing chromatographic methods of analysis and chemical and spectral methods of identification have been explained by Geissman[3], Harborne[4], Mabry[5] et al, Jay[6] et al, Markhand[7] and Linskens and Jackson[8]. The conventional chromatographic methods like column, paper and thin layer are still in use for separation and purification of the flavonoid compounds Increase in speed and efficiency in the separation of mixtures had been achieved by high pressure liquid chromatography (HPLC). Among the separation techniques applied to flavonoids HPLC has the advantage over to other techniques[9] in regard to sensitivity, rapidity and easy quantification. Hosttettman and Hosttetman[10] reviewed the relevant literature on HPLC upto 1980. A few other publications in this field include $R_f$ values by Daigle and Conkeston[11], use of Bondpak $C_{18}$ with MeOH-HOAC-$H_2O$ as developing system with two pumps by casteele[12] et al, analytical problems in HPLC by Bankova[13] et al, Tamma[14] et al and Barberan[15] et al. The application of HPLC combined with FABMS in the structural elucidation of anthocyanin pigments was explained by J.B.Harborne and R.J. Grayer[16]. On line HPLC-UV, flash chromatography[17,18], centrifugal TLC[19-21] using chromatogram are also applied in the isolation of flavonoids. For difficult separations requiring very high resolution semi preparatory HPLC with automatic fraction collector is an ideal method. Reverse phase chromatography[22-25], HPLC-DAD and HPLC-MS[26] on chemically bonded phases gives better results of separation of plant phenolics.

The complication of irreversible adsorption and decomposition of the solute at the liquid-solid interface in all techniques employing a solid stationary phase and liquid mobile phase is overcome by various support free liquid-liquid partition techniques, DCCC[27,28] and RLCC[29] have been employed profitably for quantitative and qualitative separation by Hosttetman and collaborators[30], Aritani[31] et al and Gunasegaran[32] et al. However, the constant need in natural product chemistry to separate large and small quantities of complex mixtures efficiently and rapidly is unfortunately seldom satisfied by the use of any one chromatographic technique. The best results have been obtained by a combination of several techniques, which are often complementary.

Paper electrophoresis[33] is a technique of limited application in flavonoid analysis, since to be mobile, a flavonoid must be in an ionized state at the $p^H$ of the electrolyte. Its useful application lies in the recognition and identification of flavonoid sulfates[34,35] and in the distinction of glucuronides from glycosides[36]. Relative nobilities of different flavonoid sulfates are listed by Hosttetman[37]. Electrophoresis finds greater application in the field of anthocyanins and betacyanin.

The flavonoid once isolated as a homogenous compound is characterized by the specific colour tests[38], physical constants[39], elemental analysis[40], $R_f$ values[41] in various solvent systems, analysis of hydrolysis products, preparation of derivatives and comparison of these data with related compounds[42]. Further support for confirmation of the structure of the flavonoid is achieved by the analysis of different spectral data (UV-VIS, IR, MS, $^1H$ and $^{13}C$ NMR).

Ultraviolet spectroscopy[43] is still on the oldest and useful techniques for flavonoid identification. The UV spectrum with MeOH and with diagnostic shift reagents can give information on the type of flavonoid as well as its substation pattern. The use of $AlCl_3$ and $AlCl_3$/HCl UV spectra in the precise determination of the structure of flavonoid compound was demonstrated by voirin[44] and limitation of NaOAc spectra in flavonoid analysis has been reported by Rosler et al[45].

IR spectroscopy[46] provides valuable information regarding the type of flavonoid as well as the nature of the substituents like methoxy, methoxy dioxy and phenyl oxy groups. It is also used as a "finger-printing" devise for establishing the identity of two samples.

Mass spectrometry of flavonoids serves as a valuable aid in determining the molecular weight and probable structure even with very small sample size. The electron impact mass

spectrometry (EIMS)[47] is used for the volatile compounds, the non-volatile compounds are converted to suitable derivatives like trimethyl silyl ether, per methyl ether, methyl ester or similar derivatives. Field desorption mass spectrometry (FD-MS) employed for polar and thermolabile compounds like flavonoids has been reviewed by Schulten and Games[48]. Desorption chemical ionization mass spectrometry (DCI-MS)[49] using electrically heated tungsten probe and fast atom bombardment mass spectroscopy (FABMS)[50] using the sample solubilized in polar matrix (like glycerol, Thio glycerol etc.,) deposited in a copper target, which is bombarded with energized neutral atoms to induce ionization and desorption[51] appears to be the most advantageous one for the analysis of flavonoid glycosides, when two MS are linked in tandem, it has now become possible to employ the first as separator and the second as analyzer to perform direct mixture analysis (Tandem-MS). This multiple stage MS has been reviewed by Roush et al[52]. In the chemical ionization mass spectrometry (CI-MS)[53] the ions are formed in ion molecular collisions which include abstraction as primary process using weak gas phases like $CH_4$, $NH_3$, $I^-$, $C_4H_{10}$ in positive CI for protonation. In negative CI, $OMe^-$ as reagent for proton abstraction or $CI^-$ as an attachment reagent is employed. The MS analysis of per methyl ether of glycosides is widely employed for settling structural problems in C-glycosyl flavones[54,55]. Pyrolysis ionization mass spectrometry of flavonoids under positive and negative ionization conditions is observed[56] to yield data characteristic of both aglycone and sugar residues, providing an alternative for FD and FABMS techniques. The easy MS differentiation of flavanones and dihydoro flavonols by characteristic fragments has been reported[57]. The application of GC-MS[58] analysis to pre deuteron methylated derivatives of flavonoids[59] has rendered the identification of certain methoxylated compounds easier. On line HPLC-MS[60] will be readily accepted by flavonoid researchers. Becchi and Fraisse[61] have reported mass analyzed ion kinetic energy (MIKE) and collision activated dissociation. MIKE spectra of flavonoids providing characteristic fragment ions, which permit differentiation of the 6- and / or 8- substituent location and the position of O-glycosylation. Solution phases secondary ion mass spectrometry[62] has proved useful in the determination of molecular weight of complex flavonoid glycosides. Electrospray MS 114 has become quite versatile on account of the amenability of the technique to highly polar and large seized molecules including bio molecules like proteins recently ESI and MALDI-TOF mass spectrometry in the study of flavonoids and selected components of biological interest have been used[63,64].

Nuclear Magnetic Resonance (NMR) over the last twenty-five years has given considerable encouragement to structural elucidation in all fields of natural product chemistry. The proton magnetic resonance spectroscopy is the established nondestructive method of flavonoid analysis. Use of high field magnets and computer assistance has made the recording of high resolution $^{1}H$ NMR spectra of minute quantity of flavonoids[65-68]. Typical application of $^{1}H$ NMR includes determination of oxygenated pattern, number of methoxy groups, distinction of isoflavones, flavonones and dihydroflavonols, number and nature of sugar present (Whether α- linked or β- linked) and detection of hydrocarbon side chain. Shift reagent provide a method of spreading out PMR absorption signals. The use of lanthanide shift reagents in positioning of methoxy groups of flavonoids was reported by Joseph Nathan and et al[69].

Of late $^{13}C$ NMR spectroscopy[70-75] has become the most useful technique for the structural determination of flavonoids. $^{13}C$ resonance signals extending over 200 ppm provide the nature of the carbon skeleton. Carbon relaxation time measurement being less difficult is very useful in differentiating otherwise non discernable carbon atom like C-6 and C-8 in flavonoids inter glycosidic linkages in the case of disaccharides[76] (rutinose, neohesperidose etc.,) type of linkage with aglycone and sugars conjugation with sulfates and organic acids can also be determined. Homonuclear and heteronuclear correlation spectroscopy[77] (HOMCOR and HETCOR) and the various decoupling experiments have reduced the difficulty in the interpretation of $^{1}H$ and $^{13}C$ NMR spectra of complex molecules. Fourier transform NMR employing popular pulse sequences like off-resonance, hetero nuclear decoupling, inverse gated hetero nuclear decoupling and selective proton decoupling has eased the task of assignment of peaks in a $^{13}C$ NMR spectrum. Refocused INEPT with decoupling is an alternate of off-resonance decoupling for assigning carbon multiplets. J-Modulated spin echo[78] spectroscopy is yet another method of off-resonance decoupling which gives positive signal for carbon with even number of hydrogen ($CH_2$ and quaternary) and negative signal for carbon with odd number of hydrogen (CH and $CH_3$) attached. At present 2D NMR[79,80] methods make it more acceptable to natural products chemistry with the requirement of decreased sample size usually a set of routine 2D experiments[81] including COSY [(HOHAHA), 2D NOE (NOESY/ ROESY) and HECTOR (HMQC)] are used in the structural elucidation of flavonoids. Recently NMR techniques have been extended to clarify the anti- oxidative molecular mechanism of catechins[82].

Over the past 40 years, chiroptical methods like ORD and CD spectral analysis have been employed for the determination of stereochemistry of chiral flavonoids[83,84]. The excitation chirality method[85] employing the application of coupled oscillators in determining the chirality of natural products is receiving greater attention.

If the flavonoid compounds can be obtained in a fine crystalline form, X-ray analysis can help in further confirming the structure as reported in the case of calycopterin[86].

Final confirmation is always desired to be established by unequivocal total synthesis. The conventional methods of synthesis of flavonoids from simple precursors by condensation methods have been proposed by Algar and Robinson[87], Algar and Flynn[88] and Baker and Venkataaman[89]. These methods of synthesis have been modified by Farkas[90] et al and Wagner[91] et al as illustrated by the synthesis of a number of flavonoids and their methyl ethers. Many flavonoid compounds have been prepared by simple modification of the existing structure through nuclear oxidation, nuclear reduction, isomerisation, selective alkylation and dealkylation, selective glycosylation and partial hydrolysis. Wagner[92] et al accomplished the synthesis of methoxylated flavones from the corresponding brominated methoxy chalcones. The synthesis of 5, 6, 7, 3', 4'-penta methoxy flavones (sinensetin) by dehydrogenation of the corresponding flavonone with $SeO_2$ has been achieved by Wagner[93] et al. This flavone has been used as the starting material for the synthesis of a number of related flavones. Bose[94] et al have reported cyclisation and simultaneous dehydration of the hydroxyl chalcone to the corresponding flavones by heating with palladium on charcoal. A short and facile synthetic route to hydroxylated flavones has been reported by Nagarathnam and Cushman[95].

The synthesis of flavonoid glycosides have been achieved using the α-acetobromosugars of pentoseses, hexoses or disaccharides and the aglycones in the presence of catalysts. The selective glycosylation of 7-OH has been achieved by Zemplen and Farkas[96]. Syntheses of other glycosides have been accomplished by tans acylation methods by Nogradi[97] et al and Wagner[98] et al. The total synthesis of C-glycosyl flavones has been reported by Eade[97] et al and other complex ones has been provided by later workers[98,99]. The Chiron approach to the total synthesis of natural products[100] might become a useful guide in the synthesis of Chiral flavonoid compounds. Thus, the synthesis of almost all types of mono and di-C-glycosyl flavones and flavones C-glycosyl-O- glycosides has been accomplished[101], synthesis of some novel flavonoids has been illustrated by Rakosi[102] et al. Studies of the selective O-alkylation and dealkylation of flavonoids with anhydrous $AlBr_3$ were reported by Horie et al[103].

## REFERENCES


1. Peach, K. & Tracey, M.V. (1956) "Modern Methods of Plant Analysis". Vol. III, Springer- Verlag, New York.
2. Harborne, J.B., (1988)"" Phytochemical Methods" (2nd Edition) Chapman and Hall, New York.
3. Geissamn, T.A.& Hinreiner, E.B. (1952) Bot. Rev., 18, 77.
4. Harborne, J.B. & Boardley, M. (1983) Phytochemistry, 24, 273.
5. Mabry, T.J.,Markham, K.R.& Thomas, M.B. (1970) "Systematic Identification of Flavonoids", Springer-Verlag, New York.
6. Jay. M., Gonnet, J.F., Wollenweber, E., & Voirin, B. (1975) Phytochemistry, 14, 1605.
7. Markham, K.R. (1982) "Techniques of Flavonoids Identification", Academic Press,London.
8. Linskens, H.F. & Jackson, J.F. (1987). "Modern Methods of Plant Analysis", Vol. V, Springer-Verlag, Berlin.
9. Pryde, A., 7 Gilbert, M.T., (1979) "Application of High-Performance Liquid Chromatography" Chapman and Hall, London.
10. Hostettmann, K. & Hostettman, M (1982) in "The Flavonoids"-Advances in Research Since 1976", (Harborne, J.B & Mabry, T.J. Eds) Chapman and Hall, London, P.1
11. Daigle, D.L. & Conkerton, E.J. (1982) J. Chromatogr., 240, 202-205.
12. Casteele, K.V., Giger, H., & Vansumere, C.F., (1982) J. Chromatogr., 240, 81.
13. Bankova, V.S., Popov, S., & Marekov, N.L. (1982) J. Chromatogr., 242, 135.
14. Tamma, R.V., Miller, G.C. & Everett, R. (1985) J. Chromatogr., 322, 236.
15. Barberan, F.A.T., Nunez, J.M., & Tomas, F. (1985) Phytochemistry, 24, 1285.
16. Harborne, J.B., & Grayer, R.J. (1988) in "The Flavonoids – Advances in Research since1980", (Harborne, J.B. Ed) Chapman and Hall, London, P.1.
17. Still, W.C., Kahn, M., & Mitra, A. (1978) J. Org. Chem., 43, 2123.
18. Haberlein, H., Boonen, G., & Beck, M.A. (1997) Planta Medica, 63, 63.
19. Hostettmann, K., Hastettmann, M., & Sticher, O. (1980) J. Chromatogr., 202, 154. Pinder, A.R. (1985) Edn. in Chemistry, 22, 141.
20. Hamburger, M., Gupta, M. & Hostetmann, K. (1985) Planta Medica, 51, 215.
21. Blunt, J., Colder, V.L., Fenwick, G.D., Lake, R.J., Mocombs, J.D., Munro, M.H.G. & Preey, N.B. (1987) J. Nat. Prod., 50, 290.
22. Kabzinki, A.K.M., Rozga, M., Wysokinska, H. & Skrzypek, Z. (1997), HerbaPolonica,

43, 347.

23. Alcantara-Licudine, J.P., Bui, N.L., Kawate, M.K., Li, Q.X. (1998) Journal of Agricultural and Food Chemistry, 46, 1005.
24. Chauhan, S.K., Singh, B.P. & Agarwal,S. (1999) Indian Drugs, 36, 41.
25. Bilia, A.R., Fumarola, M., Gallori, S., Mazzi, G. & Vincieri, F.F. (2000) Journal of Agricultural and Food Chemistry, 48, 4734.
26. Hostettmann, K. (1983) in Advances in Chromatography", (Giddlings, J.C. et al Eds) Marcel Dekker, New York, p.165.
27. Conway, W.D. (1990) "Counter Current Chromatography: Apparatus, Theory and Applications", VCH, Weinheim.
28. Hiller, W., Klaiber, I., Prawat, H., Roos. G., Vogler, B., Walter, C.U. & Krasu, W (1996) Phytomedicine, 3, 166.
29. Hostettmann, K. & Hostettmann, M. (1982) in "The Flavonoids- Advances in Research", (Harborne, J.B. & Mabry, T.J. Eds) Chapman and Hall, London, p.10.
30. Aritomi, M., & Kawasaki, T., (1984) Phytochemistry, 23, 2043.
31. Gunasegarn, R., Recio, M.C., Alcaraz, M.J. & Nair, A.G.R. (1993) Pharmazie, 48, 151. Kreuzale, F. & Hanhlbrock (1973). Phytochemistry, 12, 1149.
32. Harborne, J.B. (1977) in "Progress in Phytochemistry", (Reinhold, L.Et al Eds) Vol. IV, Pergamon Press, Oxford, P. 189.
33. Markhan, K.R. (1980) "Biochemical Systematics and Ecology", Academic Press, London, P.8.
34. Verpoorte, R. (1986) J. Nat. Prod. 49,1.
35. Hostettmann, K. & Hostettmann, M. (1982) in "The Flavonoids-Advances in Research", (Harbone, J.B. & Mabry, T.J. Eds.) Chapman and Hall, London, p.10.
36. Harborne, J.B. Mabry, T.J. & Mabry, H. (1975) "The Flavonoids", Chapman and Hall, London.
37. Harborne, J.B. & Mabry, T.J. (1982) "The Flavonoids-Advances in Research since 1976", Chapman and Hall, London.
38. Harborne, J.B. (1988) "The Flavonoids"-Advances in Research since 1980", Chapman and Hall, London.
39. Cody, V., Middleton, E. Jr. & Harborne, J.B. (1986) "Plant Flavonoids in Biology and Medicine", Vol. I, Alan R. Liss, New York.
40. Middleton, E.Jr & Kandaswami, C. (1993) in "The Flavonoids-Advances in Research since 1986", (Harborne, J.B.Ed) Chapman and Hall, London, p.619.

41. Mabry, T.J., Markham, K.R. & Thomas, M.B. (1970) "Systematic Identification of Flavonoids"", Spronger-Verlag, New York.
42. Voirin, B (1983) Phytochemistry, 22, 2107.
43. Rosler, K.H.A., Wong, D.P.C & Mabry, T.J. (1985) J. Nat. Prod., 48, 837.
44. Kover, O. & Wilkins, C.K. (1971), Tetrahedron, 27, 5459.
45. Kingston, D.G.I. (1979). J. Nat. Prod., 47, 197.
46. Schulten, H.R. & Games, D.E. (1974) Biomed. Mass Spec. 2,120.
47. Hostettmann, K., Doumas, J., & Hardy, M. (1981) Helv. Chim. Acta., 64,298.
48. Saito, N., Timberlake, C., Tucknott, O.G. & Lewis, I.A.S. (1983) Phytochemistry, 22, 1007.
49. Fenselau. C. (1984) J. Nat. Prod., 47, 215.
50. Roush, R.A. & Cooks, R.G. (1984). J. Nat. Prod., 47, 197.
51. Bouillant, M.L., Bonvin, J.F., & Chopin, J. (1975) Phytocheistry, 14, 2267.
52. Chopin, J., Bouillant, M.L. & Besson, E., (1982) om "The Flavonoids- Advances in Research", (Harborne, J.B. et al Eds) Chapman and Hall, London, P.482.
53. Madhusudanan, K.P., Bhakuni, D.S., Nair, A.G.R. & Mohandoss, S. (1988). Indian J. Chem. 27B, 744.
54. Blaze, F., Crins, W.J., Bonh, B.A. & Towers, G. H. N. (1988), Phytochemistry, 27, 2715.
55. Williams, D.H. & Fleming, I. (1988) "Spectroscopic Methods in Organic Chemistry", IV Edition, Tata Mc Graw Hill, New Delhi.
56. Petit, G.R., Holzapfel, C.W. & Cragg, G.M. (1984) J.Nat. Prod., 47, 941.
57. Mann, M. &Wilm, M. (1995) Trends in Biochemical Series, 20, 219.
58. Domon, B. & Hosttetmann, K. (1985) J. Nat. Prod., 49, 456.
59. Becchi, M. & Fraisse, D. (1989) Biomed. Environ. Mass Spec., 18, 122.
60. Bouillant, M.L., Besset, A., Bonvin, J.F. & Chopin, J. (1978) Phytochemistry, 17, 527.
61. Miketova, P., Schram, K.H., Whitney, J.L., Kerns, E.H., Valcic, S., Timmermann, B.N. & Volk, K.J. (1998) J. Nat. Prod., 61, 461.
62. Pietta, P.G., Mauri, P.L., Pasqualucci, C., Gardana, C. & De Bellis, G.L. (1997) Phytomedicine, 3, 165.
63. Joseph- Nathan, P., Abramo-Bruno, D. & Torres, Ma. A. (1981) Phytochemistry, 20, 313.
64. Markham, K.R. (1993) in "The Flavonoids-Advances in Research Since 1986" (Harborne, J.B.Ed) Chapman and Hall, London.

65. Ternai,B. & Markham, K.R. (1976) Tetrahedron, 32, 2607.
66. Ternai, B. & Markham, K.R. (1976) Tetrahedron, 32, 565.
67. Chari, V.M., Wagner, H., & Neszmelyi. (1977) in "Flavonoids and Bioflavonoids", (Farkas, L. et al Eds) Elsevier Publishing Co., Amsterdam, p.49.
68. Markham, K.R., & Chari, V.M. (1982) in "The Flavonoids-Advances in Research", (Harborne, J.B. et al Eds) Chapman and Hall, London, p.19.
69. Agarwal, P.K. (1989) "$^{13}$C NMR of Flavonoids", Elsevier, Amsterdam.
70. Horie. T., Ohtsuru. Y., Shibata. K., Yamashita, K., Tsukayama, M. & Kawamura, Y. (1998) Phytochemistry, 47, 865.
71. Ndjoko, K., Wolfender, J.L., Roder, E. & Hostettmann. K. (1999) Planta Medica, 65, 562.
72. Bosco, M., Toffanin, R., Palo, D., Zatti, L., & Segre, A. (1999) J. of the Science of Food and Agriculture, 79, 869.
73. Nair, A.G.R. & Gunasegaran, R. (1982) Indian, 21B, 1135.
74. Shoolery, J.M (1984) J. Nat. Prod., 47, 226.
75. Nakanishi, K., Goto. T., Ito, S., Natori, S. & Nozoe, S. (1986) "Natural Products Chemistry", Vol III, University Science Books, California.
76. Budzianowski, J. (1991) Phytochemistry, 30, 1679.
77. Tomas-Lorente, F., Garcia-Grau, M.M., Neito, J.L. & Tomas-Barbean, F.A. (1992) Phytochemistry, 30, 1678.
78. Agarwal, P.K. (1994) J. of Sci. of Indus. Res., 53, 329.
79. Sawai, Y., Sakata, K. (1998) J of Agricultural and Food Chemistry, 46, 111.
80. Levai, A., (1977) in "Flavonoids and Biflavonoids". (Farkas, L. et al Eds) Elsevier Publishing Co., Amsterdam, p.295.
81. Herada, N. & Nakanish, K. (1983) "Circular Dichroic Spectroscopy-Exciton Coupling in Ogganic Stereochemistry", University Sciences Books, Oxford.
82. Mabry, T.J. & Markham, K. R, (1975) in "The Flavonoids", (Harborne, J.B. & Mabry, T.J.Eds) Chapman and Hall, London, p.78.
83. Vijayalakshmi, J., Rajan, S.S., Srinivasan, K. & Nair, A.G.R. (1986) Acta Cryst., C 42, 1752.
84. Algar, J. & Robinson, R. (1924) J. Chem. Soc., 2192.
85. Algar, J.&Flynn, J.P. (1934) Proc. Roy Iriah. Acad., 42B, 1.
86. Baker, W. & Venkataraman, K. (1962) in "Chemistry of the Flavonoids Compounds", (Geissman, T.A. Ed) Pergamon Press, Oxford, p.160.

87. Farkas, L., Strelisky, J. & Major, A. (1967) in "Progress in Chemistry of Organic Natural Products", (Zechmeister, J.Ed) Springer-Verlag, New York, p.163.
88. Wagner,H., Aurnhammer, G., Horhammer, L., Farkas, L., & Nogradi, M. (1968) Tetrahedron Letts., 1635.
89. Wagner, H., Hoer, R.,Murakami, T., & Farkas, L., (1973) Chem. Ber. 106, 20.
90. Bose, P.K., Chakrabarthi, P. & Sanyal, A.K. (1970) J. Indian Chem. Soc., 48, 1163.
91. Nagarathnam., D., & Cushman, M., (1991) J. Org. Chem., 56, 4884.
92. Zemplen, G. & Farkas, L. (1943) Ber. Dt.Chem. Ges.,76,110.
93. Nogradi, M., Farkas, L., Wagner, H. & Horhammer, L. (1967) Chem. Ber., 100, 2783.
94. Wagner, H., Budweg, W., Horhammer, L. Vermr, B. & Farkas, L. (1981) Chem. Ber., 104, 2118.
95. Eade,R.A., Mc Donald, F.J. & Pharm, H.P. (1987) Aust. J. Chem., 31,2699.
96. Farkas, L., Gottsegen, A., Nogradi, M. & Antus, S. (1974) J. Chem. Soc., Perkin Trans, 1305.
97. Chopin, J., Bouillant, M.L. & Besson, E. (1982) in "The Flavonoids-Advances in Research" (Harborne, J.B.Ed) Chapman and Hall, London.
98. Hanessian, S. (1983) "Total synthesis of Natural Products-The Chiron Approach", Pergamon Press, London.
99. Boullant, M.L., Besset, A., Bonvin, F.J. & Chopin, J. (1985) Phytochemistry, 19, 1755.
100. Rakosi, M., Szegeny, A., Balint, J., & Bogner, R. (1986) in "Flavonoid and Bioflavonoids", (Farkas, L.et al Eds) Elsiever, Amsterdam, p.39.
101. Horie, T., Kawamura, Y., Tsukayama, M. & Yoshizaki, S. (1989) Chem. Pharm. Bull., 37, 2116.