

List of Figures

| | Page# |
|--|-------|
| Fig. 1.1. Schematic representation showing the free radical generation followed by the chain of by-product (ROS/RNS) formed due to oxidative stress and how they affect biological systems by cellular stress and even leading to carcinogenesis. | 4 |
| Fig. 1.2. Schematic representation showing the free radical generation followed by the chain of by-product (ROS/RNS) formed due to oxidative stress and how they affect biological systems by cellular stress and even leading to different types of mental disorders. | 6 |
| Fig. 1.3. Schematic representation showing the free radical generation followed by the chain of by-product (ROS/RNS) formed due to oxidative stress and how they affect biological systems by cellular stress and CCl ₄ induced hepatotoxicity. | 7 |
| Fig. 1.4. Schematic representation showing role of gentamicin in the induction of nephrotoxicity. | 8 |
| Fig. 2.1. Selected steroid phytocompounds present in different <i>Clerodendrum</i> species. | 16 |
| Fig. 2.2. Selected terpinoids present in different <i>Clerodendrum</i> species. | 17 |
| Fig. 2.3. Selected flavonoids present in different <i>Clerodendrum</i> species. | 18 |
| Fig. 3.1. Datasheet used during the collection of germplasm. | 25 |
| Fig. 4.1. Flowers and foliages of selected species of <i>Clerodendrum</i> used in the present study. | 73 |
| Fig. 4.2. Antioxidant activity of <i>Clerodendrum indicum</i> , <i>Volkameria inermis</i> , <i>C. serratum</i> and <i>Clerodendrum colebrookianum</i> . (A) DPPH activity; (B) Nitric oxide scavenging activity; (C) Super oxide radical scavenging activity; (D) Hypochlorous acid scavenging assay. | 74 |
| Fig. 4.3. Antioxidant activity of <i>C. indicum</i> , <i>V. inermis</i> , <i>C. serratum</i> and <i>C. colebrookianum</i> . (A) Lipid peroxidation activity; (B) Hydroxyl radical scavenging assay; (C) Peroxynitrate scavenging assay; (D) Hydrogen peroxide scavenging activity. | 76 |
| Fig. 4.4. Antioxidant activity of <i>C. indicum</i> , <i>V. inermis</i> , <i>C. serratum</i> and <i>C. colebrookianum</i> . (A) Singlet oxygen scavenging activity; (B) Reducing power assay; (C) Total antioxidant scavenging activity. | 77 |
| Fig. 4.5. Antioxidant activity of <i>C. indicum</i> , <i>V. inermis</i> , <i>C. serratum</i> and <i>C. colebrookianum</i> . (A) Iron chelation assay. | 78 |
| Fig. 4.6. Antioxidant activity of <i>C. indicum</i> , <i>V. inermis</i> , <i>C. serratum</i> and <i>C. colebrookianum</i> . (A) Haemolytic assay; (B) Erythrocyte membrane stabilizing activity; (C) MTT cell proliferation assay. | 80 |

Contd... to next page.

| | Page# |
|---|-------|
| Fig. 4.7. Effects of <i>Clerodendrum</i> species (CIL, VIL and CCL) on oxidative stress in the Human Hepatic Cell Line (WRL-68). (A) Control cell culture; (B) Cells exposed to 200 µg/ml concentration of H ₂ O ₂ ; (C) Cells exposed to 200 µg/ml concentration of CCl ₄ ; (D-F) Cells exposed to 200 µg/ml concentration of CIL, VIL and CCL for 24 h. | 81 |
| Fig. 4.8. Effects of <i>Clerodendrum</i> species (CIL, VIL and CCL) on oxidative stress in the human liver cancer cell line (Hep G2). (A) Control cell culture; (B) Cells exposed to 200 µg/ml concentration of H ₂ O ₂ ; (C) Cells exposed to 200 µg/ml concentration of CCl ₄ ; (D-F) Cells exposed to 200 µg/ml concentration of CIL, VIL and CCL for 24 h. | 82 |
| Fig. 4.9. Effects of <i>Clerodendrum serratum</i> (CSL) on oxidative stress in the human embryonic kidney cell line (HEK-293). (A) Control cell culture; (B) Cells exposed to 200 µg/ml concentration of H ₂ O ₂ ; (C) Cells exposed to 200 µg/ml concentration of gentamicin; (D) Cells exposed to 200 µg/ml concentration of CSL for 24 h. | 83 |
| Fig. 4.10. Antimicrobial activity of four <i>Clerodendrum</i> species namely (A) <i>C. indicum</i> ; (B) <i>C. inerme</i> ; (C) <i>C. serratum</i> and (D) <i>C. colebrookianum</i> against pathogenic bacteria <i>B. subtilis</i> . | 84 |
| Fig. 4.11. Antimicrobial activity of four <i>Clerodendrum</i> species namely (A) <i>C. indicum</i> ; (B) <i>C. inerme</i> ; (C) <i>C. serratum</i> and (D) <i>C. colebrookianum</i> against pathogenic bacteria <i>S. aureus</i> . | 85 |
| Fig. 4.12. Antimicrobial activity of four <i>Clerodendrum</i> species namely (A) <i>C. indicum</i> ; (B) <i>C. inerme</i> ; (C) <i>C. serratum</i> and (D) <i>C. colebrookianum</i> against pathogenic bacteria <i>E.coli</i> . | 85 |
| Fig. 4.13. Antimicrobial activity of four <i>Clerodendrum</i> species namely (A) <i>C. indicum</i> ; (B) <i>C. inerme</i> ; (C) <i>C. serratum</i> and (D) <i>C. colebrookianum</i> against pathogenic bacteria <i>E. aerogenes</i> . | 86 |
| Fig. 4.14. The effect of <i>Clerodendrum</i> extracts (CIL, VIL and CCL) on (A) Catalase activity; (B) Peroxidase activity; (C) Reduced Glutathione (GSH) activity; (D) Superoxide Dismutase (SOD) activity; (E) Lipid Peroxidation (LPO) activity; (F) NO release. CILL: <i>C. indicum</i> Low Dose; VILL: <i>V. inermis</i> Low Dose; CCLL: <i>C. colebrookianum</i> Low Dose; CILH: <i>C. indicum</i> High Dose; VILH: <i>V. inermis</i> High Dose; CCLH: <i>C. colebrookianum</i> High Dose. | 89 |
| Fig. 4.15. Photomicrographs (100×) of the histopathological examinations of the liver samples of different groups. | 91 |
| Fig. 4.16. Photomicrographs (400×) of the histopathological examinations of the liver samples of different groups. | 91 |
| Fig. 4.17. Effect of CSL extract on scopolamine-induced memory impairment in the passive avoidance test. (A) AChE (B) DPPH (C) Lipid peroxidation (D) Catalase (E) GSH and (F) SOD activity of CSL extract. | 94 |

Contd... from previous page.

| | Page# |
|---|-------|
| Fig. 4.18. Photomicrograph of control and treated mice brain (cortex, A-E), 40X. | 95 |
| Fig. 4.19. Photomicrograph of control and treated mice brain (Hippocampus region, A-E), 40X. | 96 |
| Fig. 4.20. The effect of CSL extract on (A) Superoxide Dismutase (SOD) activity. (B) Reduced Glutathione (GSH) activity. (C) Lipid Peroxidation (LPO) activity. (D) Catalase activity. | 98 |
| Fig. 4.21. Photomicrograph of control and treated rats kidney (A-E). | 100 |
| Fig. 4.22. FTIR analysis of three <i>Clerodendrum</i> sp., (A) <i>Clerodendrum indicum</i> ; (B) <i>Volkameria inermis</i> ; (C) <i>Clerodendrum colebrookianum</i> . | 101 |
| Fig. 4.23. GC-MS fingerprinting of four <i>Clerodendrum</i> sp., (A) <i>Clerodendrum indicum</i> , (B) <i>Volkameria inermis</i> , (C) <i>Clerodendrum serratum</i> and (D) <i>Clerodendrum colebrookianum</i> . | 103 |
| Fig. 4.24. List of some chemical compounds identified in the four <i>Clerodendrum</i> extracts by GC-MS analyses. | 104 |
| Fig. 4.25. Molecular docking image. Molecular docking (molecular surface view) between Nrf2 protein and 24, 25-Dihydroxyvitamin D. | 106 |
| Fig. 4.26. Molecular docking (secondary structure view) between Ap1 protein and Ethyl iso-allocholate. | 106 |
| Fig. 4.27. Molecular docking interactions of Stigmasterol with Hepatitis BX (3i7h). | 108 |
| Fig. 4.28. Molecular surface view of NF- κ B (1nfi) protein with Ethyl iso-allocholate. | 109 |
| Fig. 4.29. Molecular docking representation of dopamine receptor D3 (3pbl) protein with Stigmasterol. | 110 |
| Fig. 4.30. <i>In-silico</i> docking representation of stigmasterol with Polycystic Kidney Disease protein 2 (5T4D). | 111 |
| Fig. 4.31. FTIR spectra of (A) fraction-1 and (B) fraction-2. | 113 |
| Fig. 4.32. ^{13}C NMR spectra (A) and ^1H NMR spectra (B) of fraction-1 (Squalene). | 115 |
| Fig. 4.33. ^1H NMR spectra (A) and ^{13}C NMR spectra (B) of fraction-2 (linolenic acid methyl ester). | 116 |
| Fig. 4.34. Antioxidant activity of two isolated compound squalene and linolenic methyl acid ester (A) DPPH activity; (B) Nitric oxide; (C) Hydrogen peroxide and (D) Reducing power assay. | 118 |
| Fig. 4.35. Zone of inhibitions/Antimicrobial activity of two isolated compound squalene and linolenic acid methyl ester against various pathogens (A) <i>B. subtilis</i> ; (B) <i>S. aureus</i> ; (C) <i>E. coli</i> and (D) <i>P. aeruginosa</i> using agar well diffusion assay. | 119 |

Contd... to next page.

| | Page# |
|---|-------|
| Fig. 4.36. Stages of callus induction and regeneration. (A) Callus induction, (B) Formation of <i>in-vitro</i> shoot, (C) Development of leaves, (D) <i>In-vitro</i> root induction, (E) Plantlet with well developed roots, (F) Different stages of shoot induction, (G) Acclimatization of plant in clay pot containing mixture of soil and sand. | 121 |
| Fig. 4.37. DNA fingerprinting pattern of <i>in-vitro</i> callus regenerated plantlets of <i>C. thomsoniae</i> . (A) using RAPD primer OPA 13 and (B) using ISSR primer UBC 808. | 125 |
| Fig. 4.38. GC-MS fingerprinting of (A) field grown plant and (B) tissue culture plant. | 127 |
| Fig. 4.39. Molecular surface view of BDNF protein with (A) 3-Hydroxybutyric acid and (B) Pyroglutamic acid docked into its binding site. | 128 |
| Fig. 4.40. Crude DNA of all the <i>Clerodendrum</i> samples. | 130 |
| Fig. 4.41. Representatives of RAPD profiling of 11 accessions of <i>Clerodendrum</i> amplified with (A) OPA12, (B) OPA 16, (C) OPA 18 and (D) OPN 19 primers. | 133 |
| Fig. 4.42. Dendrogram obtained from UPGMA cluster analysis of RAPD markers illustrating the genetic relationships among the 11 accessions of <i>Clerodendrum</i> . | 134 |
| Fig. 4.43. Principal coordinate analysis of 11 species of <i>Clerodendrum</i> based on RAPD analysis data. (A) 2-dimensional plot and (B) 3-dimensional plot. | 134 |
| Fig. 4.44. ISSR banding patterns of 11 accessions of <i>Clerodendrum</i> generated by (A) UBC811, (B) UBC 815, (C) UBC 841 and (D) UBC 873 primers. | 136 |
| Fig. 4.45. Dendrogram generated from the cluster analysis of ISSR markers of 11 <i>Clerodendrum</i> accessions. | 137 |
| Fig. 4.46. Principal coordinate analysis of 11 species of <i>Clerodendrum</i> based on ISSR analysis data. (A) 2-dimensional plot and (B) 3-dimensional plot. | 137 |
| Fig. 4.47. Amplification of 11 species of <i>Clerodendrum</i> with matK primer. | 138 |
| Fig. 4.48. Restriction digestion products of matK region of chloroplast genome by (A) HaeIII and (B) HpaII. | 140 |
| Fig. 4.49. A dendrogram based on the restriction digestion products data of the matK region of 11 species under the genus <i>Clerodendrum</i> . | 140 |
| Fig. 4.50. Amplification of 11 species of <i>Clerodendrum</i> with Rps 16 primer. | 141 |
| Fig. 4.51. Restriction digestion products of Rps 16 region of chloroplast genome by (A) EcoRI and (B) HaeIII. | 142 |

Contd... from previous page.

| | Page# |
|--|-----------|
| Fig. 4.52. A dendrogram based on the restriction digestion products data of the Rps16 region of 11 species under the genus <i>Clerodendrum</i> . | 142 |
| Fig. 4.53. Amplification of 11 species of <i>Clerodendrum</i> with Tab c-f (TrnL-TrnF) primer. | 143 |
| Fig. 4.54. Restriction digestion products of TrnL-TrnF region of chloroplast genome by (A) EcoRI and (B) HaeIII. | 144 |
| Fig. 4.55. A dendrogram based on the restriction digestion products data of the TrnL-TrnF region of 11 species under the genus <i>Clerodendrum</i> . | 144 |
| Fig. 4.56. (A) Snapshot of partial matK gene sequence of <i>Clerodendrum indicum</i> submitted to GenBank (NCBI). (B) Snapshot of partial rps16 gene sequence of <i>Clerodendrum japonicum</i> submitted to GenBank (NCBI). (C) Snapshot of partial trnL-trnF Intergenic Spacer (IGS) sequence of <i>Clerodendrum colebrookianum</i> submitted to GenBank (NCBI). | 146-148 |
| Fig. 4.57. Most parsimonious tree (neighbour joining method) showing the relationship of matK region of 26 different taxa (A); Rps16 region of 20 different taxa (B) and TrnL-F region of 21 different taxa (C). | 150 & 151 |
