2. LITERATURE SURVEY

2.1. MEDICINAL PLANTS OF TRIPURA, INDIA

The northeastern states of India are inhabited by a large number of various ethnic groups. More than 130 major tribal communities and more than 300 sub groups with distinct cultural entities inhabit the region. Nineteen tribal communities also live in Tripura and they have immense knowledge about indigenous medicinal plants of the state. The knowledge and utilization of local plants varies between the ethnic groups, their location and also on their remoteness from the modern world [13]. The literature on ethnomedicinal plants of Tripura and their traditional uses extensively searched. But it was observed that very limited ethnobotanical surveys had carried out in Tripura in spite of its vast potential. List of different ethnobotanical survey conducted on Tripura are listed in Table 2.1.

<table>
<thead>
<tr>
<th>Author</th>
<th>Number of plants reported</th>
<th>Study area</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Majumdar et al., 2006 [79]</td>
<td>33 plants (from 31 genera of 25 families)</td>
<td>Several tribal villages</td>
<td>Plants are prescribed by tribal and non-tribal medicine men (Auchai, Ozai, Kabiraj) of Tripura for treatment of different diseases</td>
</tr>
<tr>
<td>Sankaran et al. 2006 [80]</td>
<td>Fruits of 40 plants</td>
<td>Tripura</td>
<td>Fruits of these plant have economic and great nutritional value</td>
</tr>
<tr>
<td>Authors</td>
<td>Plants</td>
<td>Districts/Genus/Provinces</td>
<td>Uses</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>--------</td>
<td>---------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Majumdar and Datta, 2007 [81]</td>
<td>50 plants (from to 46 genera of 31 families)</td>
<td>West and South Tripura district</td>
<td>Plants are generally prescribed by Ochai to treat several ailments, some of the plants are also used as vegetable commonly</td>
</tr>
<tr>
<td>Das et al., 2009 [82]</td>
<td>33 plants (from 32 genera of 25 families)</td>
<td>Tribal villages of Tripura</td>
<td>Plants used by the Tripuri and Reang tribes</td>
</tr>
<tr>
<td>Shil &amp; Dattu Choudury, 2009 [83]</td>
<td>16 plants (from 14 genera of 10 families)</td>
<td>Different villages of Tripura</td>
<td>These 16 pteridophytic floras are used by the Reang tribes</td>
</tr>
<tr>
<td>Shil &amp; Dattu Choudury, 2009b [84]</td>
<td>58 plants (from 57 genera of 39 families)</td>
<td>Dhalai district</td>
<td>Plants are used by the Reang tribes</td>
</tr>
<tr>
<td>Das et al., 2010 [85]</td>
<td>63 plants</td>
<td>Tripura</td>
<td>Plants are used by the tribes of Tripura to treat common ailments</td>
</tr>
<tr>
<td>Das et al., 2010b [86]</td>
<td>Fruits of 28 plants</td>
<td>Tripura</td>
<td>Plants are important in folk medicinal system of Tripura</td>
</tr>
<tr>
<td>Das &amp; Datta Chaudhury, 2010 [87]</td>
<td>26 plant</td>
<td>North Tripura</td>
<td>Twenty one plants are used against gastrointestinal troubles and five plants are used to treat hemorrhagic condition</td>
</tr>
<tr>
<td>Chaudhury et al., 2010 [88]</td>
<td>10 plants (from 9 families)</td>
<td>Tripura</td>
<td>The fruits of the plants are edible and widely consumed by the tribes of Tripura</td>
</tr>
</tbody>
</table>
Three books describing the medicinal plants of Tripura also reviewed to gather the information about the folk uses medicinal plants of Tripura.

Chakraborty N in his book documented 287 species of different medicinal herb and shrub of Tripura. Some of these are also used as vegetable, spice, animal food, green fertilizer, preparation of wine, and as a raw material in industry. The book includes 193 dicot plants from 5 families and 94 monocot plants from 15 families. Excess use of 15 plants may produce poisonous effect [89].

Chakraborty N in his another book described 351 plants. Most of the plants discussed in the book have medicinal value and used for every almost all ailments in daily life. Some of the plants have no medicinal value but used by people as vegetable and in different industries [90].

A book entitled ‘Medicinal Plants of Tripura’ described the botanical information and medicinal importance of 203 medicinal species with photographic illustration. The book also contains some lesser known plant of Tripura [91].

2.2. LITERATURE REVIEW ON ANTIOXIDANT ACTIVITY

Aiyegoro and Okoh (2010) investigated the in vitro antioxidant activities of the aqueous extract of *Helichrysum longifolium* DC. Extract showed the positive result for tannins, flavonoids, steroids and saponins. The total phenolic content, total flavonoid and proanthocyanidin contents of extract were 0.499, 0.705 and 0.005 mg gallic acid equivalent/g of extract. Extract exhibited potent 2,2-diphenyl-1-picrylhydrazyl radical (DPPH), 2,2'-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical, O$_2^-$, H$_2$O$_2$, and NO’ scavenging and significant lipid peroxidation inhibition effect [92]
Antioxidant activity of *Cyperus rotundus* rhizomes extract was determined by Nagulendran et al. (2007) using several *in vitro* free radicals and ROS scavenging assay method. Extract showed concentration dependent by $O_2^{•−}$, $OH^•$, NO$, H_2O_2$ scavenging, metal chelating and reducing power ability. The extract was found effective in preventing mitochondrial lipid peroxidation induced by FeSO$_4$/ascorbate in concentration dependent manner in young and aged rat brain mitochondria [93].

Asokkumar et al. (2010) evaluated antioxidant and hepatoprotective activities of different fractions of hydromethanolic extract of the *Ficus macrocarpa* leaves. *In vitro* and *ex vivo* antioxidant activities was measured by DPPH$, NO^•$, $O_2^{•−}$, $OH^•$, $H_2O_2$ scavenging assay, reducing power ability, chelating activity, beta carotene bleaching, total peroxyl radical assay, total antioxidant activity, lipid peroxidation assay and total antioxidant capacity in human plasma method. Fractions showed concentration dependent antioxidant activity, though none of the fractions exerted an obvious pro-oxidant activity in compare with ascorbic acid. Fractions significantly prevent carbon tetrachloride induced hepatotoxicity evident by the increase in liver CAT, SOD, GPx, GSH level and decrease in lactate dehydrogenase (LDH), lipid peroxidation and malondialdehyde (MDA) level [94].

Antioxidant activity and NO scavenging effect of methanol extracts, and their ethyl acetate fraction from *Uraria crinita* root were evaluated by Yen et al. (2001). Both extract and fraction produce concentration dependent NO$^•$ scavenging effect, effectively inhibit DNA damage in macrophage induced by sodium nitroprusside, and produce significant antioxidant activity determined by Trolox equivalent antioxidant capacity assay. Genistein, a major antioxidative component was isolated from the fraction [95].
Antioxidant activities of polar fractions of mature garlic (*Allium sativum*) bulbs and immature plants (bulbs with steam and leaves) were investigated by Bozin et al. (2008). Extracts reduced the DPPH’ formation (IC$_{50}$ = 1.03 to 6.01 mg/ml) and neutralised H$_2$O$_2$ (IC$_{50}$ = 0.55 to 2.01 mg/ml) effectively. All extracts produce strong inhibition of lipid peroxidation. Different levels of phenolics (0.05-0.98 mg gallic acid equivalents/g of dry extract) and flavonoid aglycones (4.16-6.99 μg quercetin equivalents/g of dry extract) was determined in the investigated extracts, which may be responsible for its observed antioxidant activity [96].

Coulibaly et al. (2011) evaluated the protective effect of *Scoparia dulcis* on neuroinflammation and erythrocytes haemolysis. Acetyl cholinesterase inhibition, brain protective assay, protection of rat erythrocytes against haemolysis, carboxyesterase inhibition assay were used to evaluate the protective effect of hexane, chloroform, methanol and aqueous-acetone extract of *Scoparia dulcis*. Extracts showed significant protective role against lipid peroxidation induce in brain and erythrocytes. Hexane and methanol extract produce more potent cytoprotection activity. Presence of antioxidant components like flavonoidic polyphenols may be responsible for its observed effects [97].

Harlalka et al. (2007) evaluated protective effect of *Kalanchoe pinnata* against gentamycin induced nephrotoxicity in rats. Treatment with aqueous extract of *K. pinnata* found effective when administered at a dose of 125 mg/kg for 8 days. *In vitro* antioxidant study showed the dose dependent DPPH’, NO’ scavenging activity of extract. The reducing power capacity and anti lipid peroxidation effect of extract was also determined. Pretreatment with extract significantly decreases creatinine, blood urea and blood urea nitrogen (BUN) level [98].
Tai et al. (2011) performed antioxidant activity and isolated chemical constituents of edible flower of *Sophora viciifolia*. The antioxidant activity is evaluated by DPPH•, ABTS•, ferric reducing antioxidant power (FRAP), reducing power and inhibition of lipid peroxidation models. The highest antioxidant effect was exhibited by ethyl acetate soluble fraction, may be due to the presence of flavonoids. Among 11 compounds isolated from this flower, luteolin was present at the highest concentration (5.56 mg/g dry sample) and showed potent DPPH• scavenging effect [99].

Antioxidant and radical-scavenging activities of water and methanol extracts of Japanese persimmon leaf tea were studied by Sakanaka et al. (2005). Methanol extract produced potent and higher antioxidant activity tested by b-carotene bleaching and O$_2$•− scavenging method. While water extract showed better DPPH• scavenging activity. Extract also showed potent OH• scavenging activity of the extracts, which is comparable to ascorbic acid. These results justify the antioxidant potential of persimmon leaf tea [100].

Rumbaoa et al. (2009) performed phenolic content and antioxidant capacity of four variety of Philippine potato (*Solanum tuberosum*) tubers using ferric thiocyanate (FTC), DPPH• scavenging, reducing power ability, iron chelating capacity assay method. Methanolic potato extracts had better antioxidant capacity than α-tocopherol and better iron chelating activity than ethylenediamine tetraacetic acid (EDTA). The total phenolic content of potato varieties reported. Different among the four samples *Bengeuta* had the highest phenolic content [101].

In vivo and in vitro antioxidant activity of polyphenolics extract from *Pinus koraiensis* seed was investigated by Su et al. (2009). The total phenolic content of extract was 264 mg of gallic acid equivalents/g dry material. The extract
demonstrated remarkable scavenging activity on DPPH•, OH•, O₂•−, and potent reducing power ability. Extract also showed strong inhibitory effect on rat liver lipid peroxidation and erythrocyte haemolysis. Extract exhibited protective effect against oxidative damage induced by D-galactose and γ-ray [102].

Liu and Yao (2007), evaluated the antioxidant potential of different extracts from barley using reducing power ability, DPPH• and lipid oxidation inhibition method. Acetone (70%) extract showed presence of highest contents of total phenolics and proanthocyanidins and produce better activity than 70% ethanol and 70% methanol extract [103].

Gulchin (2006) investigated antioxidant potential of caffeic acid by ABTS•, DPPH• and O₂•− scavenging activity, total antioxidant activity, total reductive capability, and metal chelating activities. Caffeic acid (10-30 μg/ml) showed 68.2 and 75.8% inhibition on lipid peroxidation of linoleic acid emulsion respectively. In addition, caffeic acid is also found effective in ABTS•+, DPPH•, O₂•− scavenging, and showed significant total reducing power ability and metal chelating effect on ferrous ions activities [104].

Antioxidant activity of cold water, hot water, methanol extract of *Pleurotus squarrosulus* was investigated against DPPH•, OH•, O₂•−, NO• scavenging assay, reducing power ability, ferrous ion chelating and β-carotene/linoleic acid assay method by Pal et al., 2010. Hot water extract has higher phenolic, total flavonoid, β-carotene and lycopene content and exhibit maximum antioxidant activity. In OH• scavenging assay all extract produced better effect than positive control [105].

A modified OH• scavenging assay of phenolics and flavonoids was investigated by Ozyurek et al. (2008). Modified cupric reducing antioxidant capacity
method using catalase for H\textsubscript{2}O\textsubscript{2} degradation assay was compared with high performance liquid chromatography (HPLC)/electrochemical detection techniques and deoxyribose assay. The newly investigated method might be helpful and efficient for those compounds, for which the deoxyribose assay test is basically nonresponsive [106].

\textit{In vitro} and \textit{in vivo} antioxidant potential of carotenoid lutein was evaluated by Sindhu et al. (2010). Lutein effectively scavenges O\textsubscript{2}•−, OH•, DPPH•, NO•, ABTS•, inhibit lipid peroxidation and showed ferric reducing power ability. Oral administration of lutein (50, 100 and 250 mg/kg, b.w.) inhibited superoxide generation in sodium caseinate induced macrophages \textit{in vivo} by 34.18, 64.32 and 70.22% respectively. Administration of lutein in mice for 30 days significantly increased the activity of CAT, SOD, GR and glutathione in blood and liver, while activity of GPx and glutathione-S-transferase (GST) were increased in the liver tissue [107].

\textit{In vitro} and \textit{in vivo} antioxidant activities of the aqueous extract of \textit{Celosia argentea} leaves was investigated against cadmium-induced oxidative stress in Wistar rats by Malomo et al. 2011. Extract (10 mg/ml) inhibited linoleic acid oxidation by 67.57%, and the highest reducing power ability was observed at 100 mg/ml as against 10 mg/ml for ascorbic acid. In addition, extract (2 mg/ml) also showed membrane stabilizing activity of 63.49% as against 77.46% for indomethacin. Cadmium administration decreased the uric acid, albumin, bilirubin and ALP activity of the rat liver and brain. The reduction in the SOD, CAT activity of the liver and brain, and increase in the serum MDA content in animals treated with cadmium alone was attenuated by the extract [108].
2.3. LITERATURE ON HEPATOPROTECTIVE ACTIVITY

Firdous et al. (2011) investigated protective effect of carotenoid meso-zeaxanthin against paracetamol (3 g/kg b.w., p.o.), 20% ethanol (7.5 g/kg b.w., p.o.) and carbon tetra chloride (CCl₄) (2.5 ml/kg, i.p.) induced hepatotoxicity. Levels of SGOT, SGPT and ALP, and serum bilirubin significantly decreased by meso-zeaxanthin compared to negative control group. Tissue lipid peroxidation, conjugated dienes and tissue hydroperoxides were high in the paracetamol treated control group, which were decreased by meso-zeaxanthin. Level of glutathione, SOD, CAT, GPx in liver tissue was increased by meso-zeaxanthin compared to alcohol and CCl₄ induced hepatotoxic group. Hydroxyproline also decreased remarkably by meso-zeaxanthin. Histopathological study confirms hepatoprotective potential of meso-zeaxanthin [109].

Effect of the ethanolic extract of *Hibiscus hispidissimus* on paracetamol (2.5 g/kg, p.o.) induced and CCl₄ induced liver damage in rats was studied by Krishnakumar et al. (2008). Significant hepatoprotective effects were observed against liver damage by extract as evidenced by decreased levels of SGOT, SGPT, ALP, serum bilirubin, and an almost normal histological architecture of the liver compared to the toxin controls. The extract also produced *in vitro* antilipid peroxidant effects and potent DPPH• scavenging effect [110].

Singh and Handa (1995) evaluated protective effect of *Apium graveolens* and *Hygrophila auriculata* seeds against liver damage induced by a single dose of paracetamol (3 g/kg, p.o.) and thioacetamide (100 mg/kg, s.c.). Pretreatment with methanolic extract of the seeds of both plants at 200 mg/kg exhibited a significant reduction in the paracetamol induced increase in the levels of SGOT, SGPT, ALP, sorbitol dehydrogenase, glutamate dehydrogenase and serum bilirubin. Extract also
produced similar protective activity against thioacetamide induced liver toxicity. Histopathological studies confirmed their protective effect [111].

Protective activity of hydroalcoholic extract of *Aerva lanata* against paracetamol (3 gm/kg, *p.o.*) induced liver damage in rats was evaluated by Manokaran et al. (2008). Oral administration of extract (600 mg/kg) resulted significant decrease in serum enzymes like ALT, AST, ALP and bilirubin. Silymarin (25 mg/kg) was used as reference standard [112].

Surendran et al. (2011) evaluated *in vitro* and *in vivo* hepatoprotective activity of *Cissampelos pareira* against CCl₄ induced liver damage. Treatment with hydroalcoholic extract of the plant root significantly reduced AST, ALT, ALP and serum bilirubin level to near normal. Lipid peroxidation level was significantly reduced in extract treated groups. Level of SOD, CAT, GST, GPx, GSH, triglyceride were significantly increased and cholesterol level was decreased after treatment with extract (200, 400 mg/kg). *In vitro* hepatoprotective activity was evaluated against 1% CCl₄ induced toxicity in isolated rat hepatocytes. HepG2 cells showed dose dependent increase in percentage viability at the doses 20, 40, 60, 80 and 100 μg/ml of extract compared to negative control group [113].

Naaz et al. (2007) evaluated hepatoprotective effect of ethanolic extract of *Phyllanthus amarus* on aflatoxin B1-induced liver damage in mice. Extract (0.3 g/kg, *b.w.*) decreased the content of thiobarbituric acid reactive substances (TBARS) and increased GSH, GPx, GST, SOD and CAT level. Histopathological studies of liver samples also confirmed the hepatoprotective activity of extract [114].

Hepatoprotective effect of seeds of *Cuscuta chinensis* was studied against acetaminophen (835 mg/kg, *i.p.*) induced hepatotoxicity by Yen et al. (2007). Oral administration of *C. chinensis* ethanolic extract (125 and 250 mg/kg) showed a
significant hepatoprotective evident by reduced levels of SGOT, SGPT, ALP. Ethanol extract exhibited a significant increase in the levels of SOD, CAT, and GPx, and reduced MDA levels. In contrast, aqueous extract did not produce any hepatoprotective effect. Liver histopathology also confirmed the protective effect of ethanol extract [115].

Setty et al. (2007) investigated hepatoprotective effect of hydro-ethanolic extract (70%) of *Calotropis procera* flowers. Paracetamol (2 g/kg, *p.o.*) has increased the SGPT, SGOT, ALP, bilirubin, cholesterol levels, and reduced the serum HDL, tissue GSH level. Treatment with hydro-ethanolic extract (200 mg/kg and 400 mg/kg) for 7 days had brought back the altered levels of biochemical markers to the near normal levels in the dose-dependent manner [116].

Hepatoprotective activity of peptides from *Ganoderma lucidum* was studied by Shi et al. (2008) against D-galactosamine induced hepatic injury in mice. Peptides were given daily for two weeks at varying doses. D-galactosamine cause significant increase in AST, ALT in serum and MDA level, and significant decrease in activity of SOD and GSH level in liver. Pretreatment with peptides reversed these altered parameters near to normal levels. The biochemical results were supplemented by histopathological examination of liver sections [117].

Khatri et al. (2009) evaluated hepatoprotective effect of protective activity of aerial parts of *Tephrosia purpurea* and stem bark of *Tecomella undulata* against thioacetamide-induced hepatotoxicity. Treatment with *T. purpurea* (500 mg/kg, *p.o.*) and *T. undulata* (1000 mg/kg, *p.o.*) resulted in a significant decrease in serum AST (35 and 31% respectively), ALT (50 and 42% respectively), gamma glutamyl transpeptidase (56 and 49% respectively), ALP (46 and 37% respectively), total bilirubin (61 and 48% respectively) and liver MDA levels (65 and 50% respectively),
and significant increase in liver glutathione (73 and 68% respectively) when compared with thioacetamide treated negative control rats. Histology also confirms the protective effect of tested drug [118].

*Boerhaavia diffusa* leaves extract were evaluated for antioxidant and hepatoprotective activity against acetaminophen-induced liver damage by Olaleye et al. (2010). Total phenolic, total flavonoid, vitamin C vitamin E content and the levels of selenium and zinc in ethanolic extract was 6.6 mg/g tannic acid equivalent, 0.092 mg/g quercetin equivalent, 0.21 mg/g, 0.054 mg/g, 0.52 ppm and 9.28 ppm respectively. Extract also showed potent DPPH$^\bullet$ scavenging and reductive potential ability. Pretreatment with extracts (aqueous and ethanolic) decreased the activities of serum ALP, LDH, AST, ALT and billirubin level that were elevated by acetaminophen. The extracts also found to inhibit acetaminophen induced lipid peroxidation [119].

Hepatoprotective effects of 50% ethanol eluate precipitation of *Artemisia sacrorum* was investigated on acetaminophen induced toxicity in mice by Yuan et al. 2010. Pretreated with test substance significantly prevented the increases of AST, ALT, and tumor necrosis factor-$\alpha$ (TNF-$\alpha$) levels in sera, and prevented the GSH depletion, MDA accumulation in liver tissues distinctly. Histopathological observation of liver, immunohistochemical analysis, and DNA laddering confirmed that of *Artemisia sacrorum* prevented acetaminophen-induced apoptosis and necrosis. Western blot analysis showed that test substance decreased acetaminophen -induced caspase-3 and caspase-8 protein expressions in mouse livers significantly [120].

Hepatoprotective effect of *Carissa carandas* Linn root extract against CCl$_4$ and paracetamol induced hepatic oxidative stress was evaluated by Hegde and Joshi (2009). Pretreatment with ethanolic extract of *C. carandas* root (100, 200 and 400
mg/kg, *p.o.*)) resulted significant protective effect against CCl₄ and paracetamol induced hepatotoxicity by reducing the activities of serum marker enzymes, bilirubin and lipid peroxidation, and significant elevation in the levels of uric acid, glutathione, SOD, CAT and protein in a dose dependent manner. Histopathological examination of liver and decrease in the total liver weight also confirmed the hepatoprotective activity of extract [121].

Hepatoprotective activity of alcoholic and aqueous extracts of *Tylophora indica* leaves were investigated against ethanol-induced liver damage by Gujrati et al. The alcoholic extract did not produce any mortality even at 5000 mg/kg but median lethal dose (*LD₅₀*) of aqueous extract was found to be 3162 mg/kg. Ethanol showed altered physical (increased liver weight and volume), biochemical (increase in AST, ALT, ALP, direct & total bilirubin, cholesterol, triglycerides and decrease in total protein and albumin level), histological (hepatocytes damage) and functional (spleen time induced by thiopentone) liver parameters. Pretreatment with both extract significantly prevented the alteration in physical, biochemical, histological and functional parameter caused by ethanol administration. The alcoholic extract demonstrated better hepatoprotective activity than the aqueous extract [122].

Hepatoprotective activity of ethanolic extract of *Vitex negundo* leaf was investigated by Tandon et al. (2008) against hepatotoxicity produced by administering a combination of three anti-tubercular drugs isoniazid (7.5 mg/kg), rifampin (10 mg/kg) and pyrazinamide (35 mg/kg). Ethanolic extract (250 and 500 mg/kg, *p.o.*) produced significant protective effect evident by the decrease in AST, ALT, ALP and bilirubin levels in comparison to control [123].
2.4. LITERATURE ON NEPHROPROTECTIVE ACTIVITY

Hepatoprotective effect of *Thea sinensis* melanin was studied on mice by Hung et al. Melanin (10-40 mg/kg, *i.p.*) administration 2 h before intoxication causes complete inhibition of the cisplatin (20 mg/kg, *i.p.*) induced elevation of serum BUN, serum creatinine, and prevent of oxidative stress. Cisplatin treatment increases mRNA levels for different enzymes. Melanin restored normal expression of marker genes for nephrotoxic mouse kidneys. Melanin by itself, however, did not affect the renal functional parameters (BUN and creatinine), transcription for marker genes [124].

Nitha and Janardhanan (2008) evaluated the protective effect of the aqueous-ethanol extract of cultured mycelium of *Morchella esculenta* against cisplatin and gentamicin induced acute renal toxicity in mice. Renal toxicity results increase in serum creatinine and urea levels, which were reversed by the extracts at a dose of 250 and 500 mg/kg. The decreased activity of SOD, CAT, GPx, and GSH in the kidneys consequent to cisplatin and gentamicin administration was significantly increased by the extract and restores depleted antioxidant defense system. Extracts also enhanced renal antioxidant defense system by preventing the tissue lipid peroxidation [125].

Fouad et al. (2008) evaluated nephroprotective effect of carnosine (a natural antioxidant) against cisplatin (20 mg/kg, *i.p.*) induced renal damage in mice. Carnosine (10 mg/kg/day, *i.p.*) was given for 6 consecutive days, starting 3 days before cisplatin injection. Carnosine treatment significantly inhibits the cisplatin induced elevation of BUN and serum creatinine levels. Carnosine also significantly attenuated cisplatin induced elevation in malondialdehyde and decrease GSH, CAT and SOD in renal cortical homogenates. Histopathological observation showed that carnosine markedly ameliorated cisplatin induced renal tubular necrosis [126].
Protective effect of *Cardiospermum halicacabum* was investigated against acetaminophen (750 mg/kg, *p.o.*) induced nephrotoxicity in rats by Parameshappa et al. (2012). In nephrototoxic rats, significant increase of serum ALP, creatinine, BUN, uric acid, cholesterol, and depletion of total protein, albumin level were observed. Pretreatment with methanol and petroleum ether extract at a dose of 400 mg/kg significantly reversed the biochemical parameters to normal. Methanol extract showed better effect, rutin (20 mg/kg) was used as standard. Histopathological studies also suggest the protective effect of extracts [127].

Khan et al., 2009 investigated the protective effect of green tea against cisplatin induced nephrotoxicity. Increased in the level of serum creatinine, BUN, LDH, acid phosphatase, and decrease in malate dehydrogenase, glucose-6-phosphatase, SOD, CAT, and 32Pi transport was observed in cisplatin induced nephrotoxicity group. Green tea showed protective effect that was evident by the increased in the activities of the enzymes of carbohydrate metabolism, brush border membrane, oxidative stress, and 32Pi transport [128].

Wongmekiat et al. (2008) studied the possible beneficial effect of *Allium ascalonicum* extract on renal injury caused by cyclosporine A (25 mg/kg, *p.o.*). Cyclosporine A treated rats showed increased BUN, serum creatinine, and decreased creatinine clearance, urea level. Histopathological reports confirm severe vacuolations and tubular necrosis. Oxidative stress in nephrotoxic group was evident by increased renal MDA and reduced GSH concentrations. Treatment with extract (1 g/kg) for 21 days showed its protective effect by retarding the nephrotoxicity and oxidative stress induced by cyclosporine A [129].
Effect of aminoguanidine investigated in cisplatin induced nephrotoxicity by Mansour et al. (2002). Administration of aminoguanidine (100 mg/kg/day, p.o.) in drinking water for 5 days before and 5 days after cisplatin injection (7.5 mg/kg, i.p.) showed a significant protection against nephrotoxicity. Significant reduction in serum urea, creatinine, and increase in albumin was observed in drug treated group. Urine volume, urinary excretions of albumin, GST and kidney weight were significantly reduced in aminoguanidine treated group. Treatment with aminoguanidine prevented the increase of MDA and reduction of GST and GPx activities in the kidney [130].

Mohan et al. (2010) evaluated the nephroprotective effect of *Solanum torvum*. Nephrotoxicity was induced by intravenous injection of doxorubicin (67.75 mg/kg) for 2 days prior to sacrifice. Alcoholic extract of *S. torvum* (100 and 300 mg/kg p.o.) was administered with doxorubicin and alone for 4 weeks. Levels of creatinine and BUN were decreased, and levels of SOD, CAT significant (*p* < 0.05) were increase in extract treated group. Tubular necrosis, renal lesions and glomerular congestion was observed in nephrotoxic group and was found to be reversed by extract [131].

Protective effect of aqueous extract of *Phyllanthus amarus* leaf and seed in acetaminophen (200 mg/kg, i.p.) and gentamicin (40 mg/kg, i.p.) induced nephrotoxic rat was evaluated by Adeneye and Benebo (2008). Animals were treated with a single oral dose of extract (100-400 mg/kg/day) 1 h before each dose of the nephrotoxicants for 14 days. Extracts significantly (*p* < 0.05, *p* < 0.01, *p* < 0.001) attenuated elevations in the serum creatinine and BUN levels in dose dependent manner. Histopathological studies also confirm the protective effect of extract [132].

Oktem et al. (2005) investigated effect of erdosteine in vancomycin (200 mg/kg, i.p., twice daily for 7 days) induced oxidative stress and renal impairment in
rats. Erdosteine administration (10 mg/kg/day, *p.o.*) significantly inhibit the increase of renal MDA and urinary *N*-acetyl-β-D-glucosaminidase (NAG) excretion. Erdosteine also increased the level of SOD, but did not produce any effect on CAT activity in renal tissue. Histopathological study confirms the protective effect of erdosteine [133].

Prophylactic protective effect of sesamol was investigated against ferric–nitrilotriacetate (4 mg/kg, *i.p.*) induced acute renal damage in mice by Hsu et al. (2008). Sesamol prevented acute renal injury, renal lipid peroxidation, and reduced the generation of OH\(^-\), O\(_2\)^\(-\), xanthine oxidase in mice. Histopathological observation also supports the protective effect of sesamol [134].

Parveen et al. (2009) investigated protective effect of pycnogenol, a polyphenolic compound from *Pinus maritime* in potassium dichromate (15 mg/kg, *i.p.*) induced oxidative damage and nephrotoxicity in rats. Biochemical parameters like BUN, serum creatinine, and ALP were significantly (p < 0.05) decreased by pycnogenol (10 mg/kg/day, *i.p.*, for 3 weeks) pre-treatment. Pycnogenol also ameliorated increased level of TBRS, MDA and protein carbonyl, and decreased levels of glutathione and catalase activity in the kidney homogenate. Histopathological observation also supported the effectiveness of the extract [135].

Kuriakose and Kurup (2010) investigated the effects of ethanol extract of *Aulosira fertilisima* against cisplatin (5 mg/kg, *i.p.*) induced nephrotoxicity in rats. Serum urea and creatinine levels were decreased in the ethanol extract (100 mg/kg, *p.o.*) plus cisplatin treated groups. Renal TBARS, conjugated dienes, GSH, SOD, CAT, GPx and glutathione transferase level was also estimated in nephrotoxic and drug treated group. Cisplatin results marked increase in renal oxidative and nitrosative
stress and significantly deranged renal functions where as ethanol extract treatment significantly and dose dependently restored renal functions and recovers oxidative stress [136].

Protective effect of rosiglitazone on cisplatin nephrotoxicity in mice was investigated by Kim et al. (2010). Mice were treated with rosiglitazone (10 mg/kg, i.p.) or vehicle for 3 days, followed by single injection of cisplatin (20 mg/kg, i.p.). Animals were sacrificed at 4, 24, 48, and 72 hr after cisplatin administration. Maximum toxic effect produced by cisplatin observed after 72 h. Cisplatin results a significant increase in BUN, creatinine levels, and tubular cell damage with marked tissue inflammation, which was reversed by rosiglitazone treatment. Tissue cytokines and chemokines also measured, rosiglitazone causes substantially upturned the depressed IL-10 level with simultaneous inhibition of proinflammatory cytokines and chemokines. These findings suggest the nephroprotective effect of rosiglitazone [137].

2.5. LITERATURE ON ANTIDIABETIC ACTIVITY

Onomi et al. (2004) investigated the effect of dietary sodium phytate (0.02-10%) on the hepatic and serum lipid level of rats fed with a high sucrose diet for 14 days. Hepatic and serum levels of triglycerides, cholesterol and lipogenic enzymes activities were reduced with increasing concentration of dietary phytate level. Administration of 10% sodium phytate drastically depressed growth, food intake, and serum triglyceride and cholesterol levels [138].
Anihyperglycaemic and antilipidperoxidative effects of ethanolic seed extract of *Tephrosia purpurea* was investigated by Pavana et al. against STZ (50 mg/kg, *i.p.*) induced diabetes in rats. Hyperglycemia along with altered hexokinase and glucose-6-phosphatase activities, elevated lipid peroxidation, reduced enzymatic and non-enzymatic antioxidants level was observed in diabetic rats. Extract (300 mg/kg, *b.w.*, *p.o.*) showed significant antihyperglycemic and antilipidperoxidative effects as well as improved enzymatic and non enzymatic antioxidant activities which was similar to that of glibenclamide [139].

Shu et al. (2009) investigated the antidiabetic potential of total flavonoids of *Polygonatum odoratum* in STZ induced type 1 diabetic mice and high fat diet (HFD)-alloxan induced type 2 diabetic rats. HFD was continued for 10 days, and thereafter 120 mg/kg alloxan on 11th day and 100 mg/kg alloxan on 12th day was administered to induce type 2 diabetes. Precaution was taken to avoid animal mortality rate resulted from hypoglycemia and hyperglycemia in rats with injection of alloxan. Investigated flavonoid had significant hypoglycemic effect in STZ induced diabetic mice when administered for 9 days. Daily administration with flavonoids of *P. odoratum* (50-200 mg/kg, *b.w.*) for 30 days significantly decrease fasting blood glucose in HFD-alloxan induced diabetic rats. Flavonoids of *P. odoratum* significantly increased the insulin level in HFD-alloxan induced type 2 diabetic rats and showed potent *in vitro* alpha-amylase inhibition activity in a dose dependent manner [140].

Hypoglycaemic effect of water and ethanolic extracts of three *Viscum album* subspecies (*ssp. album*, *ssp. austriacum*, *ssp. Abietis*) were investigated by Orhan et al. in normoglycaemic plus glucose hyperglycemic rat and STZ-induced (55 mg/kg, *i.p.*) diabetic rats. Extracts did not produce any effect of blood glucose levels in normal rats but prevent the drastic increase of blood glucose level after glucose
administration. Extracts also produced significant antidiabetic activity. In order to evaluate antioxidant activity of extracts, tissue MDA and GSH levels were measured and found that extract produce potent antioxidant activity [141].

Sunil et al. (2011) evaluated antidiabetic effect of *Symlocos cochinchinensis* in HFD-low STZ induced type 2 diabetic rats. In normal rat hexane extract produced mild reduction in the blood glucose level. In OGTT, treatment with hexane extract (250 and 500 mg/kg) produced 12.07 and 23.58% reduction in plasma glucose levels after 30 min of glucose administration respectively. Extract also exert improved insulin sensitivity after 60 min of insulin treatment. Twenty eight days treatment with hexane extract (250 and 500 mg/kg) reduced the plasma glucose level by 17.04 and 42.10% respectively in HFD-STZ induced diabetic rats. A significant decrease in plasma insulin, plasma and hepatic total cholesterol, triglycerides and free fatty acids and a significant raise in liver glycogen were observed in extract treated diabetic rats [142].

Dewanjee et al. (2009) isolated a tetraneortriterpenoid ‘swietenine’ from the *Swietenia macrophylla* seeds and investigated hypoglycemic activity of swietenine against STZ induced type 2 diabetes in neonatal rats. Oral administration of swietenine at 25 and 50 mg/kg/day for 5 consecutive days to diabetic rats results significant decrease in blood glucose level, swietenine also produced hypolipidemic effect in type 2 diabetic rats [143].

Antidiabetic potential of aqueous and ethanolic extracts of *Musanga cecropioides* stem bark was investigated by Adeneye et al. (2007). Oral treatment of extracts in normal and alloxan (120 mg/kg, *i.p.*) induced type 1 diabetic rats at doses of 250, 500 and 1000 mg/kg/day, for 14 days significantly lowered the fasting plasma
glucose levels in dose-dependent fashion. The ethanol extract induced better antidiabetic effect than the aqueous extract [144].

Jayakar and Suresh (2003) investigated hypoglycemic effect of aqueous and alcoholic extracts of *Aporosa lindleyana* root. The blood glucose levels were determined at 0, 1, 2 and 3 h after the treatment. The aqueous and alcoholic extracts at a dose of 100 mg/kg significantly reduced the blood glucose of normal rats. Aqueous and alcoholic extract after 3 h significantly decreased blood glucose level in alloxan induced diabetic rat from 306±3.37 to 160±2.46 and 328±4.15 to 152±3.86 mg%, respectively. Tolbutamide was used as standard [145].

Antidiabetic effect of pterostilbene and its effect on key enzymes of glucose metabolism were investigated by Pari and Satheesh (2006). STZ-nicotinadine induced type 2 diabetes model were used in this study. Diabetic rats were orally treated with pterostilbene (10, 20, 40 mg/kg) for 2, 4 and 6 weeks; pterostilbene at 40 mg/kg significantly reduces plasma glucose. A significant decrease in glucose and increase in plasma insulin levels were observed in normal and diabetic rats after pretreatment with pterostilbene for 6 weeks. Pterostilbene treatment resulted reduction in glycosylated haemoglobin level, glucose-6-phosphatase activity, fructose-1,6-bisphosphatase activity, and an increase in hexokinase activity, total haemoglobin level. Metformin was used as reference antidiabetic drug [146].

Antidiabetic effect of aqueous extract of *Cucumis trigonus* fruit was investigated Salahuddin and Jalalpure (2010) by using normal and STZ-induced diabetic rats. Extract exhibited potent hypoglycemic activity in STZ-diabetic rats, whilst there was no significant effect observed on normoglycemic rats. Treatment with extract (500 mg/kg/day for 21 days, *p.o.*) was causing significant increase in the body weight, liver glycogen, serum insulin, high density lipoprotein (HDL)
cholesterol level and decrease in the blood glucose, glycosylated hemoglobin, total cholesterol and serum triglycerides level [147].

Sharma et al. (2010) investigated antiatherosclerotic effect of aqueous leaves extract of *Morus rubra* against STZ induced diabetic rats fed with atherosclerotic diet. Treatment with extract in diabetic rats (100, 200 and 400 mg/kg/day for 30 days, *p.o.*) resulted significant decrease in fasting blood glucose in dose dependent manner. Extract showed significant improvement of body weight and serum lipid profile. Different endothelial dysfunction parameters like sVCAM-1, fibrinogen, total NO levels, oxidized low density lipoprotein (LDL), and apolipoprotein A & B were significantly reversed by extract treatment. Study proved that the extract improves homeostasis of glucose and fat and possess anti-atherosclerotic activity [148].

Srinivasa et al. (2008) evaluated the antidiabetic activity of ethanolic extract of the leaves of *Justicia beddomei* in alloxan induced diabetic rats. Extract (100 mg/kg, *i.p.*) reduced serum glucose levels by 35.6% and 39.8% at 0-8th day and 0-16th day respectively Extract (100 mg/kg) decreased the serum glucose level in alloxan induced diabetic rats from 260.83 to 157.50 mg/dl at 16th day. The antidiabetic activity of *Justicia beddomei* leaves ethanolic extract was compared with insulin [149].

Hypoglycemic and hypolipidemic potential of ethanolic extract of the aerial part of *Salvadora oleoides* in euglycemic and alloxan (120 mg/kg, *i.p.*) induced diabetic rats was evaluated by Yadav et al. (2008). Oral treatment with extract (1 and 2 g/kg) for 21 days resulted significant reduction in blood glucose level. Ethanolic extract also significantly reduced triglyceride, cholesterol, HDL, LDL, very low density lipoprotein (VLDL) level in euglycemic and alloxan induced diabetic rats after 21 days treatment [150].
2.6. LITERATURE ON ANTHELMINTIC ACTIVITY

Goswami et al. (2010) evaluated *in vitro* anthelmintic activity of ethanolic extracts of *Hedychium spichatum* rhizomes and *Zingiber zerumbet* rhizomes against *Pheritima posthuma*. Activities of extracts in different concentrations (25, 50, 100 mg/ml) were evaluated by taking varying albendazole concentrations (25, 50, 100 mg/ml) as standard. Normal saline (0.9% NaCl) was used for the control treatment and the report was given in terms of time taken for paralysis and death to the earthworms. The results found from the study indicate toward the anthelmintic activity. At 100 mg/kg concentration both standard and ethanolic extract of *Z. zerumbet* showed almost similar anthelmintic activity [151].

*In-vitro* anthelmintic effects of crude aqueous and hydroalcoholic extracts of the leaves of *Chenopodium ambrosioides*, *Lawsonia inermis* and seeds of *Jatropha curcas* was investigated on eggs and adult *Haemonchus contortus* by Eguale and Giday (2009). Extracts of *C. ambrosioides* and *J. curcas* inhibited the hatching of eggs in low concentration, while *L. inermis* did not inhibit the hatching of eggs significantly. *C. ambrosioides* extract have shown a moderate effect on survival of worm, while *J. curcas* and *L. inermis* did not produce significant effect on the survival of adult parasites at the concentrations tested [152].

Cestocidal activity of *Acacia caesia* stem bark on *Raillietina echinobothrida* was evaluated by Lalchhandama (2009). *In vitro* treatments with methanol extract of *Acacia caesia* stem bark were causes dose-dependent (0.5, 1, 2, 5, 10, and 20 mg/ml) paralytic and mortality effects on the avian gastrointestinal cestode, *Raillietina echinobothrida* Megnin. The effect of extract was similar to that of albendazole in high concentrations such as 5, 10, and 20 mg/ml. Scanning of the cestode with electron microscopy treated with 20 mg/ml of the plant extract showed profound
morphological alterations which were the deliberate hallmark effects of anthelmintic drugs [153].

Taur et al. (2010) studied the anthelmintic potency of volatile oil isolated from *Eucalyptus globulus* on adult Indian earthworms (*Pheretima posthuma*) which have anatomical and physiological resemblance with the intestinal roundworm parasites of human beings. Oil sample in concentrations of 0.05, 0.01 and 0.15 ml/ml, showed potent anthelmintic activity (paralysis and death time) as compared to that of the standard drug albendazole (10 mg/ml) [154].

Mehta et al. (2012) evaluated *in vitro* anthelmintic activity of crude petroleum ether, methanol and water extract of *Zanthoxylum armatum* seeds. Activity of all extracts (10, 25 and 50 mg/ml) were tested against *Pheretima posthuma*, and results were expressed in terms of paralysis time and time for death of worms. Piperazine citrate (10 mg/ml) was used as the standard anthelmintic agent. Aqueous extract showed more potent activity compared to other extracts [155].

Khatri et al. (2011) evaluated anthelmintic efficacy of the *Prosopis cineraria*. Different concentrations of petroleum ether, methanolic and aqueous extracts (10, 20, 30, 40, 50 mg/kg) of the bark were evaluated for anthelmintic activity on adult Indian earthworm, albendazole taken as reference standard. Paralysis time for petroleum ether, methanolic and aqueous extract at 50 mg/ml was 52.2, 25.4, 31.2 min; while death time for the same was 99.3, 38.5 and 53.5 min respectively. Paralysis and death time for albendazole (20 mg/kg) was 17.2 and 30.5 min respectively [156].

Bachaya et al. (2009) evaluated the anthelmintic activity of *Terminalia arjuna* using *in vivo* and *in vitro* methods. Anthelmintic activity of methanolic extract of *T. arjuna* bark in egg hatch and larval development tests against *Haemonchus contortus* ova and larva was performed. Lethal median concentration (LC$_{50}$) values were found
to be 645.65 and 467.74 μg/ml respectively. In adult motility assay, extract shown potent effect that was evident by the mortality of *H. contortus* at different hours post exposure. *In vivo* results shown that maximum (87.3%) egg count percent reduction in sheep administered with crude methanolic extract (3 g/kg, b.w.) for 11 days. The data demonstrated dose-dependent anthelmintic activity both in the *in vitro* and *in vivo* studies [157].

*In vitro* activity of root-tuber-peel extract of *Flemingia vestita* was evaluated against different helminth parasites (nematode: *Ascaris suum*, *A. lumbricoides*, *Ascaridia galli* and *Heterakis gallinarum*; cestode: *Raillietina echinobothrida*; trematode: *aramphistomum* sp.) by Tandon et al., 1997. Crude extract (50 mg/ml) completely immobilized the trematode and cestode in about 43 and 20 min respectively. Though extract failed to produce effects on the cuticle covered nematodes. Genistein (0.5 mg/ml), an active principle isolated from the extract caused spontaneous loss of movement (paralysis) of *R. echinobothrida* in 4.5 h. Structural alteration in the tegumental architecture of parasites was observed when treated with extract that suggests the vermifugal activity of extract against trematodes and cestodes [158].

Ethanol extract of *Platycladus orientalis* leaves was investigated for anthelmintic activity against *Pheretima posthuma* by Sutar et al. (2010). The extract (1, 2.5 and 5%) exhibited significant dose dependent anthelmintic activity determined by measurement of paralysis and death of the worm, piperazine citrate was used as standard reference and distilled water as control [159].

Anthelmintic activity of the methanolic and aqueous extracts of the aerial parts of *Costus speciosus* in Indian adult earthworms was investigated by Srivastava et al. (2011). The aqueous extract showed better effect on paralyzing the worms, in terms of
paralysis time. The aqueous extract (25, 50 100 mg/ml) demonstrated paralysis within 6.70, 3.62 and 2.55 min respectively while death was observed within 7.48, 4.48 and 3.62 min respectively. Albendazole (20 mg/ml) demonstrated paralysis at 11.65 min and death occurred after 13.67 min [160].

Deore and Khadabadi (2010) evaluated *in vitro* anthelmintic activity of *Chlorophytum borivilianum* tuber against *Pheretima posthuma* and *Ascardia galli*. Time of paralysis and time of death of worm when treated with different concentration of methanolic extract, crude saponin extract and purified saponin fraction was determined taking piperazine citrate as standard. Pure saponin fraction showed potent activity, it showed better anthelmintic activity against *Pheretima posthuma* than the standard [161].

2.7. LITERATURE ON MEYNA SPINOSA

Plants from genus *Meyna* (family Rubiaceae) include shrub or small trees. Eleven different types of species of *Meyna* are distributed in topical Asia to South East Asia [162, 163].

Earlier *Vangueria spinosa* of Fl. Br. Ind. covers a group of plants from genus *Meyna*. Therefore earlier some researchers had considered *Vangueria spinosa* as a synonym of *Meyna spinosa*, while other author used *Vangueria spinosa* as a synonym of *Meyna laxiflora* [162].

But recently the plants has been separated and classified into several species of *Meyna* including *Meyna spinosa* and *Meyna laxiflora*. Both plants are closely related but flowers of *Meyna spinosa* are crowded into fascicles and have shorter pedicels and petioles than the flowers of *Meyna laxiflora* [162].
2.7.1. Scientific Name: *Meyna spinosa* Roxb. Ex

2.7.2. Vernacular Name [164, 165, 166, 167]

- **Assamese**: Moin-tenga, Moin
- **Bengali**: Mankata, Muyna
- **Hindi**: Maina, Pundrika
- **Manipuri**: Lam heibi
- **Marathi**: Alu, Halawni
- **Oriya**: Monono, Montapoo
- **Sanskrit**: Pinda, Pindituka
- **Tamil**: Manakkarai
- **Telegu**: Cegagadda, Veliki

2.7.3. Taxonomical Classification [166]

**Kingdom**: Plantae

**Habitat**: Mesophyte

**Phylum**: Magnoliophyta

**Class**: Magnoliopsida

**Order**: Rubiales

**Family**: Rubiaceae

**Genus**: *Meyna*

**Species**: *spinosa*

**Scientific name**: *Meyna spinosa* Roxb. ex Link
Figure 2.1. Images of *Meyna spinosa*
2.7.4. Botanical Description

*M. spinosa* is a spiny, armed small tree or large shrub (height about 5-8 m). Brunches are busy; spines are axillary or spura axillary, straight, sharp (length 5-40 mm). Leaves are membranous, ovate or elliptic-oblong in shape (4-15 cm x 2.5-5 cm), densely pubescent beneath. Flowers are small, 4-5 merous, pale green or greenish white with faintly fragrant, shorter pedicels and petioles, calyx 5 toothed and corella 5 lobes. Fruits are yellowish, subglobose drupe, smooth with persistent calyx lobes. Flowers are seen in in the month of April and May; while fruits can be found in August to December [163, 167, 168].

2.7.5. Distribution

Plant is commonly available in North East India (Tripura, Arunachal Pradesh, Manipur, Assam, Meghalaya, Mizoram and Nagaland), Eastern state of India (West Bangal) and South India (Andhra Pradesh, Karnataka, Tamilnadu). Plant is also found in Bangladesh, China, Mayanmar and Malaya [163].

2.7.6. Traditional and Folk Uses of the Plant

- **Headache and hair washing**: Fruits and bark is used to cure head ach and also in washing of hairs by the Nyshi community of Arunachal Pradesh, India [169].
- **Abortifacient activity**: Rural people in Tinsukia district, Assam use seeds paste for its abortifacient activity [170]. Pulp of the ripe fruits and seeds along with 2-3 bulbs of *Allium sativum* are made into paste to prepare a pill that used for abortifacient activity by the tribes of Andhra Pradesh [171]. Polia tribes of West
Bengal prepare a pill from the paste of seeds, pulp of ripe fruit, *Allium sativum* (2-3 bulb) and of 2.5 g Hing (*Ferula asafoetida*). The pill thus prepared kept inside overnight to induce abortion up to 2 month of pregnancy [172].

- **Antidiabetic activity**: People form *Meitei* and *Meitei-pangal* communities of Manipur uses boiled extract of the fruit to cure diabetes [165].

- **Treatment of skin infection and pimples**: Tender leaves along with ginger are crushed and made into paste made, which was rubbed on the infected area of the skin in Tripura [82]. Crushed ripe fruits are crushed used on cracked heels for healing, while seed paste is applied to cure pimples [173].

- **Treatment of jaundice and hepatic disorders**: Shoots of the plant are used for the treatment of jaundice in Assam, India [167]. Decoction from fruit decoction used in the treatment of biliary complaints with hepatic congestion [163].

- **Treatment of dysentery, indigestion, intestinal worm, painful urination**: The plant is used to cure dysentery, dyspepsia, indigestion, intestinal worm, and painful urination by different groups in India [90, 166].

- **Treatment of tetanus, vertigo**: *Lodhas* uses leaf decoction with common salt (3:2) in vertigo, while *Santals* uses decoction of root bark for the treatment of tetanus [166].

- **Treatment of cough, scorpion-sting and as refrigerant, nutrients**: Fruits have good nutrientional value and used to cure cough traditionally in Tripura [90]. The plant is used in treat scorpion sting and fruit are used as refrigerant traditionally [164].

- In our ethanobotanical survey conducted on villages of West and South district of Tripura it was observed that tribal people of state also used the fruit and leaf of the plant in the treatment of skin disease, peptic ulcer, diabetes, hepatic disorder [174].
2.7.7. Phytochemical Studies

Phytochemical screening of ripe fruit pulp of the Vangueria spinosa showed that astringency, total phenolic content, condensed tannin, acid detergent fibers, neutral detergent fibers and acid detergent lignin were 0.4, 0.1, 0.5, 43.8, 30.2 and 25.6 respectively. Astringency and total phenolic contents expressed as percent tannic acid, condensed tannins as percent quebrachro tannin. Alkaloid was absent in the fruit pulp [175]. Two compounds (MS1 and MS2) were isolated from the M. spinosa ripe fruits of the plant. M1 showed strongest antimicrobial effect and spectral data of MS1 indicated that the compound would be an oleanane type triterpene having a carboxylic group and was identified as oleanolic acid [176].

2.7.8. Biological Evaluation

- Antifungal activity of methanolic extracts Meyna spinosa was investigated by Goswami et al. (2006) using agar well diffusion method against Candida albicans. Moderate activity was observed and antifungal potency of the extract was compared with commercially used antibiotic clotrimazole [177].
- Two compounds isolated from the fruits of Meyna spinosa showed antimicrobial effect on several microbial stain including Bacillus subtilis, Klebsiella pneuminiae, Escherichia coli, Staphylococcus aureus and Candida albicans. Oleanolic acid from the fruit demonstrated high antimicrobial activity against all the test organisms [176].
- Aswal et al. (1996) carried out the screening of the extract from M. spinosa except root for diuretic, analgesic, antiprotozoal (against inramoeba
histolytica), antiviral (against Ranilchetdisease virus, Vaccinia virus, Semlikiforest virus), effect on respiration, effect on preganglionically stimulated nictitating membrane contraction and gross CNS behavior activity. But the extract did not produce any significant activity [178].

- Antibacterial activities of the aqueous and methanol extracts of the dried leaves of Vangueria spinosa were carried out by the disk diffusion method against four bacterial strains, namely, Staphylococcus aureus, Bacillus subtilis, Escherichia coli, and Pseudomonas aeruginosa. Both the aqueous and the methanol extracts of Vangueria spinosa showed the strongest bactericidal activity [179].

- Antibacterial activity of ethanolic extract of Vangueria spinosa leaf was assessed in vitro when used alone and in combination with doxycycline and ofloxacin against one gram-positive and three gram-negative bacteria. The antibacterial activity was performed against K. pneumoniae, E. coli, S. aureus and P. aeruginosa [180].

- Antibacterial activity of 95% ethanol extract of M. spinosa stem was investigated by disc diffusion and broth macrodilution assay method. Extract inhibited Staphylococcus aureus, Streptococcus pyogenes, and Shigella dysenteriae microorganisms, but did not show significant effect on E. coli in disk diffusion assay method. Minimum inhibitory concentration of the bark extract of M. spinosa was found 1000 µg/ml for S. aureus, S. pyogenes and E. coli, whereas 500 µg/ml for S. dysenteriae. Extract also investigated for cytotoxicity test using brine shrimp lethality bioassay method. The LD₅₀ of stem extract of M. spinosa was found to be 40 µg/ml [181]
2.8. LITERATURE ON LEEA ASIATICA

2.8.1. Scientific Name: *Leea asiatica* (L.) Ridsdale

2.8.2. Synonym

*Leea edgeworthii, Leea aspera, Leea herbacea, Leea pinnata, Leea pumila* [182], *Phytolacca asiatica, Leea crispa* [168, 183].

Though some of the texts mentioned *Leea crispa* as different species from *Leea edgeworthii (Leea aspera)* [184].

2.8.3. Vernacular Name [185].

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<tr>
<th>Language</th>
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<td>Bengali</td>
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2.8.4. Taxonomical Classification [186]

**Kingdom** : Plantae

**Phylum** : Magnoliophyta

**Class** : Magnoliopsida

**Order** : Rhamnales

**Family** : Leeaceae

**Genus** : *Leea*

**Species** : asiatica

**Scientific name** : *Leea asiatica* (L.) Ridsdale
2.8.5. Botanical Description

A shrub, up to 2 m high, branches shallowly 8-10 angled, grooved and glabrous. Leaves are long about 32 cm; leaflets 5-7, elliptic-ovate or oblong, caudate or rhomboid, 10-15 × 3-6 cm, rounded or cordate at base, crenate-serrate, transverse verve prominent, lateral nerves upto 15-20 pairs, terminal leaflets petiolule nearly 5.5 cm long. Flowers pale green, in axillary and terminal branched cymes. Berries depressed-globular, up to 8 mm, seed wedge shaped [168].

2.8.6. Distribution

Bangladesh, Burma, India (North-East India, Karnataka, Uttarakhal, Andaman and Icobar Island).

2.8.7. Traditional and folk uses of the plant

- **Bone fracture:** The plant is used to heal bone fracture by the Siddis (a tribal community in Karnataka, India). The whole plant is grinded to make paste and applied on fractured area. The thick layer of the paste is supported by the bamboo stick and kept for 10-15 days to rejoin [187].

- **Boils and blisters:** Roots of the plant are pounded and applied on skin to cure boils and blisters in North Andaman Island, India [188].

- **Worm infection:** Tribes of Tripura uses the root paste in worm infection [174]. Root of the plant used against ring worm and guinea worm infection [184, 189, 190]. People of Meghalaya, India takes crushed tuber of *L. crispa* orally as anthelmintic [191].
Figure 2.2. Images of *Leea asiatica*
- **Gastro-endocrine diseases**: The leaf of the plant used to treat liver diseases and in diabetes by the ethnic people of Tripura, and other parts of India [174, 183].
- **Disorder of eye**: Tribal people of Uttarakhand use this plant to cure eye diseases including redness of eye as ethnoveterinary practice [192].
- **Snake bite**: Root with bark of *Boswellia serrata* is made into paste and used in case of snake bite [184, 193].
- **Wound**: Pounded leaves of *L. crispa* used to treat wounds [191].

### 2.8.8. Medicinal uses and phytochemical analysis

An extensive literature survey was carried out to find the scientific literature regarding the pharmacological and phytochemical profile of the plant. However to date there is no scientific evidence was found to support the traditional uses of *Leea asiatica.*