Hepatoprotective Effect of Indigenous Medicinal Plants: A Review

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Liver is an important part in human beings and plays a very important and major role in metabolism and excretion of xenobiotics from the body. Further, hepatotoxicity is caused by different types of toxic chemicals, such as antibiotics and chemotherapeutic agents, paracetamol (C₆H₄NO₂), thioacetamide (C₅H₅NS), carbon tetrachloride (CCl₄), silymarin (C₂₅H₂₂O₁₂), ethanol (C₂H₅OH) and excessive alcohol intake and microbes is well researched. The markedly available synthetic drugs to treat liver sickness in this condition also cause further damage to the liver. Therefore, herbal medicines have become increasingly famous and their utilization is wide-spread. In medicinal plant derived drugs, that have been utilized in the treatment of liver diseases for a long time, the protection of a healthy liver has been essential for the overall well-being of an individual. Liver injury induced by toxins is more common now-a-days. Herbal remedies are focused in the pharmaceutical industry to evolve a safe route for liver disorders and it is very low cost, no side effects compared with synthetic drugs. Therefore, hepatoprotective plants such as Avicennia alba, Anisochilus carnosus, Baliospermum montanum, Centella asiatica, Clitoria ternatea, Eclipta alba, Justicia adhatoda, Phyllanthus emblica, Pisonia grandis and Syzygium cumini were reviewed. The present review is aimed at compiling data on promising phytochemicals from medicinal plants that have been tested in hepatotoxicity models using modern scientific system.

Key words: Liver diseases, hepatotoxicity, hepatoprotective, medicinal plants, xenobiotics

Liver disease has a strong position as one of the chief health troubles in the world, with cirrhosis being the most drug-stimulated liver injury, according to the 9th most common cause of death in modern and developing countries[1]. However, it is caused by infectious agents or ingestion of toxic foods, chemical, over dose of drugs and chemicals that causes liver damage are called hepatotoxins[2,3]. It may have possible side effects of chronic medications or can be caused by chemicals, such as microcystins, as well as artificial chemicals like antibiotics, tetrachloride, chemotherapeutic agents, dimethyl nitrosamine, aflatoxin, Carbon tetrachloride (CCl₄), pyrrolizidine alkaloids, allyl alcohol, Thioacetamide (C₅H₅NS), biomobenzene[4,5]. Susceptibility of the liver to chemical attacks, which comes in close contact with many harmful substances, environmental pollutants, xenobiotics and chemotherapeutic agents could repress. However, maintaining a healthy liver is a challenge for overall health and well human being, and the treatment of such diseases by using artificial pharmaceuticals or by using separated main compounds or importance parts of indigenous medicinal plants utilized in popular medicines[6,7]. In spite of this, there are nevertheless few drugs used to treat liver diseases, with possible effects on humans[8,9]. Thus, important medicinal plants with hepatoprotective or curative process utilized for the therapy of hepatic disorders become important; mostly important subjects of studies to explain their mechanism of action and characterize the compounds that can be utilized for the increased of new hepatoprotective drugs[10-13]. Some experimental models are utilized to show the hepatoprotective action of certain medicinal plants, especially against C₂H₅NS stimulated liver damage[14,15].

HEPATOTOXICITY AGENTS

Several chemicals have been known to induce hepatotoxicity and CCl₄, C₂H₅NS, C₈H₇NO₂, C₂H₅OH
and $\text{C}_{25}\text{H}_{22}\text{O}_{10}$ are used to induce experimental hepatotoxicity in laboratory animals.

**CCl₄:**

Liver injury due to CCl₄ (fig. 1a) in rats was first reported in 1936 and broadly utilized by so many researchers[16,17]. CCl₄ toxicity depends on dosage and the duration of exposure. In low dose, effects like loss of Ca²⁺ homeostasis, lipid peroxidation and release of cytokines are produced, and apoptotic events may be generated, followed by cellular regeneration. Further, in high doses or if there is a longer exposure, the effects are more severe and the damage occurs during a longer period of time, the patient may develop fibrosis, cirrhosis, or even cancer[18], is metabolized by the cytochrome P450 dependent of monoxygenases, mainly through the CYP2E1 isoform in the endoplasmic reticulum and mitochondrial[19]. Hepatotoxicity is produced by the formation of the trichloromethyl radical (CCl₃) (fig. 1b), which is highly reactive. These radicals may saturate the organism’s antioxidant defense system, react with proteins, attack unsaturated fatty acids, generating lipid peroxidation, reduce the amount of cytochrome P450, which leads to a functional failure with the consequent lowering of protein and accumulation of triglycerides (fatty liver), and alter water and electrolyte equilibrium with an increase of hepatic enzymes in plasma[20]. Lipid peroxidation leads to a cascade of reactions, such as the destruction of membrane lipids, the generation of endogenous toxic substances, which originate more hepatic complications and functional anomalies. For this reason, lipid peroxidation is considered a critical factor in the pathogenesis of liver injuries induced by CCl₄[21]. The inhibition of the radical CCl₃ generation is a key point in the protection against the damage generated. Because of this, model is widely utilized for the evaluation of pharmaceuticals and natural products with hepatoprotective and antioxidant activity[22,23].

**C₂H₅NS:**

C₂H₅NS was particularly utilized as a fungicide to maintain agricultural citrus materials, later it was denied that is a strong potent hepatotoxin and carcinogen due to organo-sulfur-containing compound enriched with liver damaging and carcinogenic activities[24,9]. Currently, it is focused as a carcinogen, and very speedily metabolized into free radical derivatives such as C₂H₅NS sulfone, TAA-S-S-dioxide, even though it leads to lipid peroxidation, thus eventually culminates in centrilobular damages and liver injuries[15]. Earlier studies have also demonstrated that, rodents intoxicated with C₂H₅NS (fig. 2) was caused such as fibrosis, liver injury, cirrhosis and steatosis in test animals of this disease with etiology, and pathology comparable equal to the one seen in humans[25-27].

![Fig. 1: 3D structures of (a): CCl₄ and (b): CCl₃](image-url)
However, C$_2$H$_5$NS was recognized as an exemplary of liver fibrosis in rats. Though in the present scenario, the broadly utilized treatment of liver fibrosis and cirrhosis is inadequate; thus there is no effectively broadly utilized therapy that can prevent the improvement of hepatic diseases is explained. Despite, newly improved drugs have been utilized to heal liver diseases; presently these drugs have abundant side effects. There is an urgent need for alternative deputing remedies or drugs, to the treatment of chronic liver disorders to change current drugs of uncertain safety and non-effectiveness\(^\text{[28]}\). Liver markers are found of Aspartate Aminotransferase (AST), Transaminases, APT, Gamma (γ)-Glutamyl Transferase (GGT), Alanine Transaminase (ALT), lipids, bilirubin, cholesterol and proteins are discharged in the blood. As a result of cell leakage and the measurement of the serum markers of the liver could be utilized for diagnosis of injuries\(^\text{[29]}\). Many products available commercially are from herbal origin, and herbal elements and dietary supplements have power as possible choice medicines for the therapy of chronic liver diseases and associated metabolic derailments\(^\text{[30,31]}\).

C$_4$H$_9$NO$_2$:

C$_4$H$_9$NO$_2$, (fig. 3) is a widely used analgesic, antipyretic drug and hepatocellular injury through three mechanisms, independently or in association. It produces acute liver damage in high doses\(^\text{[5]}\) and is a widely used experimental model of clinical importance as an example of drug-induced liver damage\(^\text{[20]}\). At therapeutic doses, it is mainly metabolized to glucuronic or sulfated and excreted derivatives, the rest metabolizes to intermediate reactives, which are eliminated by conjugation with glutathione. The 1$^{\text{st}}$ and most common mechanisms is ingestion of doses higher than 10 g by adults and up to 150 mg/kg by children, popularly known as “overdose” and 2$^{\text{nd}}$ is the cytochrome P450 at N-acetyl-p-benzoquinone (NAPQI), which quickly attaches to glutathione, resulting from the use of enzyme inducing drugs and chronic alcohol abuse, 3$^{\text{rd}}$ occurs with glucagon depletion in hepatocytes through alcohol intake or malnutrition\(^\text{[32]}\). Under excessive conditions of NAPQI and glutathione depletion, a covalent bond of metabolite to proteins, adduct formation, mitochondrial dysfunction and oxidative stress occurs. The result is necrosis or hepatocellular death\(^\text{[33]}\).

C$_2$H$_5$OH:

The liver is the most susceptible organ to the toxic effects of C$_2$H$_5$OH (fig. 4). Damage mechanism is due to the metabolism of ethanol by the CYP2E1 isoform of the cytochrome P450 producing oxidative stress with the generation of reactive species of oxygen and the increase of lipid peroxidation, leading to the alteration of the compositions of phospholipids of the cellular membrane\(^\text{[34]}\). Membrane lipid peroxidation results in the loss of its structure and integrity, elevating serum levels of glutamyl-transpeptidase, a membrane bonding enzyme. C$_2$H$_5$OH inhibits glutathione peroxidase; it reduces the activity of catalase and superoxide dismutase\(^\text{[20]}\). The decrease in the activity of antioxidant enzymes, superoxide dismutase and peroxidase glutathione is believed to come as a result of the harmful effects of free radicals produced after exposure to C$_2$H$_5$OH or alternatively, they could be a direct effect of acetaldehyde, a product of C$_2$H$_5$OH oxidation\(^\text{[35]}\).
C_{15}H_{22}O_{10}:

C_{15}H_{22}O_{10} (fig. 5) is an important component of *Silybum marianum*. Thus, it has been evidenced to be mostly hepatoprotective and has been utilized for the therapy of abundant liver disorders such as cirrhosis, fatty acid infiltration due to alcohol and toxic chemicals, and hepatitis, it’s specifically characterized by functional impairment or deterioration of necrosis\(^{[36]}\). However, it’s mechanisms of the process is not entirely understood, it appears that it acts in various ways, including anti-inflammatory activities and antioxidant, membrane stabilizer, cell permeability regulator, inhibiting the deposition of collagen fibers and stimulating liver regeneration, which may lead to cirrhosis\(^{[37]}\).

**Liver function markers:**

Functions performed by the liver, there is a wide range of markers through which we are able to determine the functionality or damage generated by this organ or its cells\(^{[38]}\). Although there is no biochemical marker specific to liver damage, the combination of several of these and knowing the correlation they have with the liver, will help to better interpret the results of the hepatoprotective models. Markers can be divided
into tests related to the liver’s excretory function (bilirubin), tests related to synthetic function (albumin and prothrombin time) and tests related to the integrity of hepatocytes (APT, Alkaline Phosphatase and GGT).

HEPATOPROTECTIVE PLANTS

The medicinal plant plays a key role in the human health care. About 80 % of the world population relies on the use of traditional medicine which is predominantly based on plant materials[39]. Traditional medicine refers to a wide range of ancient natural health care practices including folk/tribal practices as well as Ayurveda, Siddha, Amchi and Unani. These medicinal plant practices originated from time immemorial and developed gradually, to a large extent, by relying or based on practical experiences without significant references to modern scientific principles. This estimated that about 7500 plants are used in local health traditional in, mostly, rural and tribal villages of India. Out of these, the real medicinal plant value of over 4000 plants is either little known or hitherto unknown to the mainstream populations. This is classical system of medicine such as Ayurveda, Siddha, Amchi, Unani and Tibetan use about 1200 plants[40,41]. Plants based therapeutics for liver diseases has been used in India for a long time and has been popularized world over by leading pharmaceuticals. The despite their important popularity several plant medicines in general and for liver diseases in particular they are still unacceptable treatment modalities for the liver diseases. Medicinal plant remedies are focused in the pharmaceutical industry to evolve a safe route for liver disease (Table 1). Hence, in this review we focused on some medicinal plants such as *Avicennia alba*, *Anisochilus carnosus*, *Baliospernum montanum*, *Centella asiatica*, *Clitoria ternatea*, *Eclipta alba*, *Justicia adhatada*, *Phyllanthus emblica*, *Pisonia grandis*, *Syzgium cumini*.

### *Avicennia alba* (Blume):

*Avicennia alba* (Avicenniaceae family), is used in Indian system of medicine for the treatment of several types

| S.no | Plant/Tamil name | Family | Part used | Constituents | Hepatotoxicity inducing agents |
|------|------------------|--------|-----------|--------------|-------------------------------|
| 1    | *Aegle marmelos* (Tamil name-Vilvam) | Rutaceae | Leaves | Saponins, flavonoids, glycosides, alkaloids and tannins, 8-sitosterol, betalain and neoandrographolide | C₈H₁₀NO₂ |
| 2    | *Agrimonia eupatoria* | Rosaceae | Whole plants | Alkaloids-β-carboline-1-propionic acid, 6-methoxy-β-carboline-1-propionic acid, 6-methoxy-β-carboline-1-y-propionic acid (ervolamine) and aervolane (3-(6-methoxy-β-carboline-1-y) propionic acid) Flavanoids-Kaempferol, quercetin, isorhamnetin, isorhamnetin 3-O-β-[4-p-coumaroyl-α-rhamnosyl, galactoside and flavanone glycoside persinol | C₈H₁₆NO₂ |
| 3    | *Aerva lanata* Linn (Srupeelai) | Amaranthaceae | Coarse powder plant material | Alkaloids-β-carboline-1-propionic acid, 6-methoxy-β-carboline-1-propionic acid, 6-methoxy-β-carboline-1-y-propionic acid (ervolamine) and aervolane (3-(6-methoxy-β-carboline-1-y) propionic acid) Flavanoids-Kaempferol, quercetin, isorhamnetin, isorhamnetin 3-O-β-[4-p-coumaroyl-α-rhamnosyl, galactoside and flavanone glycoside persinol | C₈H₁₆NO₂ |
| 4    | *Acacia confusa* | Leguminosae | Bark | Flavonoids, phenolic acids, tannins and phenolic diterpenes | CCl₄ |
| 5    | *Agrimonia eupatoria* | Rosaceae | Whole plants | 8-sitosterol, betalain and neoandrographolide | C₇H₁₂OH |
| 6    | *Aloe barbadensis* Mill. (Kattalai) | Liliaceae | Aerial part | Flavanoids, hydroxyanthraquinones and coumarin | CCl₄ |
| 7    | *Alchornea cordifolia* | Euphorbiaceae | Leaves | Saponins, alkaloids, carbohydrates, reducing sugar, tannins and flavonoids | C₈H₁₄NO₂ |
| 8    | *Andrographis paniculata* (Tamil name-Nilavembu) | Acanthaceae | Leaf, aerial parts | Andrographolide, bicyclic diterpene, lactone, kalmegh, andrographolide | C₈H₁₂NO₂ |
| 9    | *Artemisia absinthium* L. (Tamil name-Masipathiri) | Asteraceae | Aerial parts, leaf | Tricyclene, α-thujene, α-pinene, sabinene, 6-methyl-5-hepten-2-one, α-phellandrene | CCl₄ |
| 10   | *Artemisia sacrorum* Ledeb. | Compositae | Aerial parts | 1,8-cineole, chrysanthene, chrysanthol (and its acetate), α/β-thujones and camphor | C₈H₁₄NO₂ |
| No. | Species                                | Family       | Part(s)            | Constituents                                                                 | Solvent(s) |
|-----|----------------------------------------|--------------|--------------------|------------------------------------------------------------------------------|------------|
| 11  | *Astragalus polysaccharides*           | Magnoliaceae | Dried fruits       | Flavonoids, non-protein, amino acid, saponins, alkaloids, nitro chemically compounds, mucilage, sterols, proline content and phenolics | CCl₄       |
| 12  | *Asteracantha longifolia* L.(Neermulli) | Acanthaceae  | Leaved axil, flower, root, seed | Andrographolide                                                               | C₆H₁₁NO₅  |
| 13  | *Azadirachta indica* (Vembu)          | Meliaceae    | Whole parts        | Azadirachtin, margolone, mono-, di-, sesqui- and triterpenoids, coumarins, chromones, lignans, flavonoids and other phenolics | C₂H₉NO₂    |
| 14  | *Baliospernum montanum* (Tamil name-Nakatanti) | Euphorbiaceae | Root              | Alkaloids, phenols, carbohydrates, tannins, sterols, saponins, flavonoids, cardiac glycosides, proteins, terpenoids, resinsand glycosides | CCl₄       |
| 15  | *Byrsocarpus coccineus* Schum         | Connaraceae  | Leaf               | Alkaloids, tannins, cardiac glycosides, steroids, terpenoids, flavonoids, anthraquinones, phlobatannins, reducing sugars and saponins | CCl₄       |
| 16  | *Bauhinia variegate* L.               | Leguminosae  | Stem bark          | Terpenoids, flavonoids, tannins, saponins, reducing sugars, steroids and cardiac glycosides | CCl₄       |
| 17  | *Cassia tora* L. (Thangarai)          | Caesalpiniaceae | Leaves, seeds    | Alkaloids, steroids and phlobatannins, phenolics and flavonoids, saponins and cardiac glycosides and tannins | CCl₄       |
| 18  | *Citrus limon* L. Burm. (Elumichai)   | Rutaceae     | Fruits             | Coumarins, flavonoids, carotenes, terpenes and linalool                        | CCl₄       |
| 19  | *Cleome viscosa* Linn                 | Capparidaceae | Leaf powder        | Alkaloids, flavonoids and fatty acids are the major active constituents of this genus, six main flavonoid glycosides such as kaempferol, chrysoeriol, isorhamnetin, chrysoeriol-7-O-xyllosid, kaempferol-3-galactorhamnoside and isorhamnetin 3-O-8-dapio furanosyl and B-D galactopyranoside | C₆H₉NO₂    |
| 20  | *Curcuma longa*                       | Zingiberaceae | Rhizome            | Curcumin, turmerone, monoterpenes, 5% curcuminooids, minerals, carotene and vitamin C, α-bisabolol, α-bisabolol oxide A and B, chamazulene, sesquiterpenes; coumarins: umbelliferone; flavonoids: luteolin, apigenin, quercetin and spiroethers: enyn dicycloether | C₆H₉NO₂, C₄H₁₄Cl₂NO₂ |
| 21  | *Chamomile capitula*                  | Compositae   | Whole parts        | Scoparone, melanettin, quercetin hyperoside, luteolin, dulcitol, luteolin and glycoside | C₆H₉NO₂    |
| 22  | *Cuscuta reflexa* Roxb                | Cuscutaceae  | Whole plant        | Alkaloids, aaponins, carbohydrates, glycosides, fixed oils and fats, aminoacids, flavanoids, anthraquinones, tannins and phenolic compounds. isorhammitine-3-O rutinoside, 1 tetradecanol, p-hydroxybenzaldehyde, 6,10,14-trimethyl-2-pentadecanone, ursolic acid, glycerol monotetracostanoate, 4-coumaric acid, nicotinamide, methyl hexadecanoate, sitosterol, sitosterylglycoside, cadabicine, octadecanoic acid, rutin and stachydrine | C₆H₉NO₂    |
| 23  | *Cassia occidentalis*                 | Caesalpinaceae | Whole plant       | Phenylpropanoid and phenylethanoid glycosides, flavonoids, diterpenoids and iridoids | CCl₄       |
| 24  | *Capparis spinosa*                    | Capparidaceae | Root, bark         |                                                                                                                                                             | CCl₄       |
| 25  | *Clerodendrum inerme*                 | Verbenaceae  | Leaves             |                                                                                                                                                             | CCl₄       |
26. *Decalepis hamiltonii* Wight. Asclepiadaceae  
Root  
4-Omethylresorcylaldehyde, benzyl alcohol, β-caryophyllene and α-atlantone. Aromatic aldehydes, monoterpenes, hydrocarbons, alcohols and ketones, β-phellandrene and trans-anethole. Tannins, Triterpenoid compounds such as α-amyrin, uvaol, ursolic acid, 19α-hydroxyursolic acid and 19α, 24-dihydroxyursolic acid. Tannins, saponins, steroids and/or triterpenes, alkaloids, anthraquinones, flavonoids, lactones/esters, protein and/or amino acids and carbohydrates and/or glycosides.

27. *Diospyros malabarica* Kostel. Ebenaceae  
Bark  
CCl₄

28. *Diplotaxis acris* Boiss. Compositae  
Seeds  
Aromatic aldehydes, monoterpene, hydrocarbons, alcohols and ketones, β-phellandrene and trans-anethole. Phenolic petrosins, onitin and onitin-9-O-glucoside, flavonoids, apigenin, luteolin, kaempferol-3-O-glucoside and quercetin-3-O-glucoside. Reducing sugars, non-reducing polysaccharides, steroids, glycosides, saponin, flavonoids, alkaloids, tannins and volatile oil.

29. *Equisetum arvense* Equisetaceae  
Aerial parts  
CCl₄

30. *Embelia ribes* Myrsinaceae  
Fruits  
CCl₄

31. *Garcinia mangostana* Clusiaceae  
Whole plant  
CCl₄

32. *Gundelia tourenfortii* Asteraceae  
Fresh edible stalk  
CCl₄

33. *Glycyrrhiza glabra L.* Leguminosae  
Glycyrrhizin from root  
CCl₄

34. *Grewia tiliaefolia* Vahl. Tiliaceae  
γ-lactones from stem bark  
CCl₄

35. *Halenia elliptica* Gentianaceae  
Whole plant  
CCl₄

36. *Hygrophila auriculata* Heine. Acanthaceae  
Root  
CCl₄

37. *Indigophora tinctorea* (Avuri) Fabaceae  
Whole plant  
C₈H₉NO₂

38. *Justicia simplex* D. Don. Acanthaceae  
Whole plant  
CCl₄

39. *Juncus subulatus* Juncaceae  
Powdered tubers  
C₈H₉NO₂

40. *Kyllinga nemoralis* L. Cyperaceae  
Rhizome  
CCl₄

41. *Kalanchoe pinnata* Pers (Runa kalli) Crassulaceae  
Leaves  
CCl₄

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| No. | Species Name          | Family            | Part(s)         | Constituents                                                                 | Chemical Formula |
|-----|----------------------|-------------------|-----------------|-------------------------------------------------------------------------------|------------------|
| 42  | Kigelia africana     | Bignoniaceae      | Leaves          | Flavonoids, steroidal saponins, napthoquinones and volatile constituents      | C_{8}H_{9}NO_{2} |
| 43  | Laggera alata D. Don | Sch.-Bip.         | Whole plant     | Triterpenes, flavonoids, alkaloids, polyphenols, sterols and saponins         | CCl_{4}          |
| 44  | Ligustrum robustum   | Oleaceae          | Leaves          | Terpenoids, saponins, polyphenols (especially flavonoids), glycosides and     | CCl_{4}          |
|     | Roxb.                |                   |                 | many other compounds                                                         |                  |
| 45  | Luffa echinata       | Cucurbitaceae     | Fruits          | Lucosides C, E, F, H, a mixture of alpha-spinasterol, alpha-spinisteryl      | CCl_{4}          |
|     |                      |                   |                 | glucoside, stigmasteryl-beta-D-glucoside and methyl ester                   |                  |
| 46  | Lactuca sativa       | Asteraceae        | Whole plants    | Ursolic acid, stigmasterol, sitosterol, b-sitosterol galactoside, herniarin   | CCl_{4}          |
|     |                      |                   |                 | and Z, 4, 6-trihydroxyethylbenzoate                                         |                  |
| 47  | Macrotyloma uniflorum| Fabaceae          | Seeds           | Flavonoids and tannins                                                       |                 |
|     |                      |                   |                 | Hydrocarbons, hexacosane, pentacosane, heptacosane, pentacosane hexacosane,  |                 |
|     |                      |                   |                 | (E)-phytol, thymol, hexanoic acid, acetic acid, nonacosane, 1,2,4-            |                 |
|     |                      |                   |                 | trimethylbenzene                                                             |                 |
| 48  | Moringa oleifera     | Moringaceae       | Seed            | Flavonoids, terpenoids, steroids                                              | C_{8}H_{9}NO_{2} |
| (Murungai maram) |                  |                   |                 | Saponins, tannins, flavonoids, steroids, triterpenes, coumarins, quinones,   |                 |
|     |                      |                   |                 | organic acids and alkaloids                                                  | CCl_{4}          |
| 49  | Myrtus communis      | Myrtaceae         | Leaves          | Glucose, tannin, fat, resin, metarbin, alkaidal nelumbine                      | C_{8}H_{9}NO_{2} |
|     | Linn                 |                   |                 | Alkaloid, tannin, saponin, steroid phlobatannin, terpenoid, flavonoid,       | CCl_{4}          |
|     |                      |                   |                 | cardiac, glyceride                                                           |                  |
| 50  | Momordica dioica     | Cucurbitaceae     | Leaves          | Alkaloid, glycosides, proteins, amino acids and saponins                      | CCl_{4}          |
|     |                      |                   |                 | Cardenolides, alkaloid, saponins and steroidal compounds, fixed oil, volatile |                 |
|     |                      |                   |                 | oil, resin, alkaid, triterpenoid, carisol, carissic acid and ursolic acid     |                 |
|     |                      |                   |                 | Phyllanthin, niranthin, hypophyllanthin, alkaloid, lignas, vitamin-C, quercetin, |                 |
|     |                      |                   |                 | astrogain, querscitrin, rutin, glucoflavon, linoleic, linolenic, acid         |                 |
|     |                      |                   |                 | Coumarins, tannins, and polyphenols, gallic acid, ellagic acid, brevifolin,   |                 |
|     |                      |                   |                 | carboxylic acid, ethyl brevifolin, carboxylate, methyl brevifolin, carboxylate, |                 |
|     |                      |                   |                 | lizuka, geranin, corilagin, phyllanthusin D amarin, amarinic acid,            | C_{6}H_{13}NO_{5}, |
|     |                      |                   |                 | eelaeocarpusin, geraniinic acid B, repandusinic acid, Amarulone, Furosino,    | C_{6}H_{13}NO_{2} |
|     |                      |                   |                 | 1,6-Digalloyl glucopyranoside, catechin, Epicatechin, galocatechin,            |                 |
|     |                      |                   |                 | epigallocatechin, epicatechin epicatechin 3-o-galate, epigallocatechin 3-o-    |                 |
|     |                      |                   |                 | galate                                      |                  |
| 51  | Nelumbo nucifera     | Nelumbonaceae     | Leaves          | Alkaloids, tannin, flavonoid, cardenolides, alkaloid, saponins and steroidal  | C_{8}H_{9}NO_{2} |
|     | Gaertn.              |                   |                 | compounds, fixed oil, volatile oil, resin, alkaid, triterpenoid, carisol,     | CCl_{4}          |
|     |                      |                   |                 | carissic acid and ursolic acid                                               |                  |
| 52  | Ocimum sanctum (Thulasi)| Lamianeae    | Leaves          | Alkaloid, flavonoid, flavonoid, cardenolides, alkaloid, saponins and steroidal | C_{8}H_{9}NO_{2} |
|     |                      |                   |                 | compounds, fixed oil, volatile oil, resin, alkaid, triterpenoid, carisol,     | CCl_{4}          |
|     |                      |                   |                 | carissic acid and ursolic acid                                               |                  |
| 53  | Ptrospermum acerifolium| Sterculiaceae     | Leaves          | Alkaloid, flavonoid, flavonoid, cardenolides, alkaloid, saponins and steroidal | CCl_{4}          |
|     |                      |                   |                 | compounds, fixed oil, volatile oil, resin, alkaid, triterpenoid, carisol,     |                  |
|     |                      |                   |                 | carissic acid and ursolic acid                                               |                  |
| 54  | Petroselinum Crispum (Mill.)| Umbelliferae | Leaves          | Alkaloid, flavonoid, flavonoid, cardenolides, alkaloid, saponins and steroidal | CCl_{4}          |
|     |                      |                   |                 | compounds, fixed oil, volatile oil, resin, alkaid, triterpenoid, carisol,     |                  |
|     |                      |                   |                 | carissic acid and ursolic acid                                               |                  |
| 55  | Pergularia daemia     | Asclepiadaceae    | Aerial part     | Alkaloid, flavonoid, flavonoid, cardenolides, alkaloid, saponins and steroidal | CCl_{4}          |
|     | Forsk.               |                   |                 | compounds, fixed oil, volatile oil, resin, alkaid, triterpenoid, carisol,     |                  |
|     |                      |                   |                 | carissic acid and ursolic acid                                               |                  |
| 56  | Phyllanthus niruri L. | Euphorbiaceae     | Aerial parts    | Phyllanthin, niranthin, hypophyllanthin, alkaloid, lignas, vitamin-C, quercetin, | C_{8}H_{9}NO_{2} |
|     |                      |                   |                 | astrogain, querscitrin, rutin, glucoflavon, linoleic, linolenic, acid         |                 |
|     |                      |                   |                 | Coumarins, tannins, and polyphenols, gallic acid, ellagic acid, brevifolin,   |                 |
|     |                      |                   |                 | carboxylic acid, ethyl brevifolin, carboxylate, methyl brevifolin, carboxylate, |                 |
|     |                      |                   |                 | lizuka, geranin, corilagin, phyllanthusin D amarin, amarinic acid,            |                 |
|     |                      |                   |                 | eelaeocarpusin, geraniinic acid B, repandusinic acid, Amarulone, Furosino,    |                 |
|     |                      |                   |                 | 1,6-Digalloyl glucopyranoside, catechin, Epicatechin, galocatechin,            |                 |
|     |                      |                   |                 | epigallocatechin, epicatechin epicatechin 3-o-galate, epigallocatechin 3-o-    |                 |
|     |                      |                   |                 | galate                                      |                  |
| 57  | Plantago major L.    | Plantaginaceae    | Seeds           | Total phenol, flavonoid and tannin                                            | CCl_{4}          |
| 58  | Platycodon grandiiflorum A. DC. | Campanulaceae | Saponins derived from root | Steroidal saponins, flavonoids, polyacetylenes, sterols, phenolics and       | CCl_{4}          |
|     |                      |                   |                 | other bioactive compounds                                                     |                  |
| 59  | Pracparatum mungo     |                    | Fermented product| Essential oils, saponins, carotenoids, lectins, vitamins, fiber and fatty acids | CCl_{4}          |
| No. | Plant Name                        | Family      | Part                | Chemical Constituents                                                                 |
|-----|----------------------------------|-------------|---------------------|--------------------------------------------------------------------------------------|
| 60  | Pterocarpus marsupium Roxb.      | Papilionaceae| Stem bark           | Protein, pentosan, mucilage, pterosupin, pseudobaptigenin, liquiritigenin, garbanzol, beta-cudesmol, pterostil-bene, parnotein, carpisin, proterol, marrsupinol, parsupin, oleandrin, tannins and ksinotanic acid, quercetin, kaempferol, epicatechin, and rutin, phytol, 1H-indene, 1-ethylideneoctahydro-7a-methyl, (1E,3a.alpha.,7a.beta.), 2H-1-Benzopyran,6,7-dimethoxy-2,2-dimethyl, inositol, 1-deoxy, 2-Methoxy-4-vinylphenol, 2-methoxy-3-2-propenylphenol, 2-Ethylacridine, Delta-selinene and fatty acids |
| 61  | Punica granatum Linn. (Maathulai)| Punicaceae   | Whole plant         | Triterpenoids, steroids, glycosides, saponins, alkaloids, flavonoids, tannins, carbohydrates and vitamin C, Volatile oils, chitrane, alpha and beta amyrin, lupeol, taraxasterol, fructose, glucose, invertase, protease, chloroplastagin, drosorone, ellipticine, zeylanone, zeylone, meritone, catechol, tannin, amino acids, plumbagic acid, Alkaloids, antraquinones, flavonoids, cardiah glycosides, phenols, quinones, reducing sugars, saponins, steroids, starch, tannins and terpenoids |
| 62  | Plumbago zeylanica               | Plumbaginaceae|                   | C_{6}H_{9}NO_{2}                                                                     |
| 63  | Physalis minima                  | Solanaceae   | Whole plant         | C_{6}H_{9}NO_{2}                                                                     |
| 64  | Pseudarthria vicida              | Fabacea      | Roots               | Leucopelargonid, Protein, fats, fibres, carbohydrates, vitamin-C, nicotinic acid, tannins, gallic acid, ellagic acid, flavin and glucose, linolenic acid, oleic acid |
| 65  | Phyllanthus emblica (Perunelli)  | Euphorbiaceae| Whole plant         | C_{6}H_{9}NO_{2}                                                                     |
| 66  | Quercus aliena Blum.             | Fagaceae     | Whole plant         | CCl_{4}                                                                               |
| 67  | Rhodococcus vitis lidae Linn.    | Ericaceae    | Leaves              | C_{6}H_{11}NO_{5}                                                                     |
| 68  | Rhoicissus tridentate Wild.      | Vitaceae     | Root                | CCl_{4}                                                                               |
| 69  | Rheum emodi Wall (Reval senni)   | Polygonaceae | Whole plants        | CCl_{4}                                                                               |
| 70  | Ricinus communis (Aamanakku)     | Euphorbiaceae| Leaves              | CCl_{4}                                                                               |

Steroids, saponins, alkaloids, flavonoids and glycosides. Dried leaves: Alkaloids, ricinine and N demethylricinine, flavones glycosides, kaempferol-3-O, kaempferol-3-O-B-D-glucopyranoside, quercetinylpyranoside, quercetin-3-O-8-B-D-lucopyranoside, kaempferol, O-B-rutinoside, quercetin-3-O-8-B-monorpenoids, gallic acid, quercetin, gentisicacid, rutin, epicatechin, ellagic acid, indole-3-acetic acid, ricinoleic, isoricinoleic, stearic and dhydroxystearic acids and also lipases and arcinine
| No. | Species Name          | Family       | Part           | Secondary Metabolites                                                                 | Chemicals |
|-----|----------------------|--------------|----------------|--------------------------------------------------------------------------------------|-----------|
| 71  | *Saururus chinensis* | Saururaceae  | Whole plant    | Isoflavons, saponins, phytosterols and phenols, flavonoids, tannins, saponins and terpenoids, essential oils from the pulp yielded carboxylic acids and esters, alcohols, aromatic hydrocarbons, 9, 12, 15-octadecatetra-1-ol, hexadecanoic acid, furfural, 24-methylene cycloartenone, stigma-4-en-3-one, lignoceric acid, β-sitosterol and its β-D-glucoside, β-amyrin, oenanolic acid, glycine, cystine, Serine, alanine and leucine, lignoceric acid, β-sitosterol, glucoside | CCl₄,     |
| 72  | *Spondias pinnata*   | Anacardiaceae| Stem heartwood |                                                                                      | CCl₄      |
| 73  | *Sarcostemma brevistigma* | Asclepiadaceae | Stem          | Bergenin, brevine, brevinine, sarcogenin, saponins, flavonoids                       | CCl₄,     |
| 74  | *Sesbania grandiflora* L. | Fabaceae  | Whole plant | Sterols, saponins, and tannins                                                      | C₂H₅NS and C₁₃H₂₃ClN₄O₃S |
| 75  | *Sesbania sesban* Mers | Fabaceae  | Leaf, Bark, Seed | Alkaloids, carbohydrates, protein, phytosterol, flavonoids, fixed oil cholesterol, campesterol, galactomannan, D-galactopyranoside | C₂H₅NS    |
| 76  | *Schisandra chinensis* | Schisandraceae | Leaves | Lignans, schizandrin, deoxyschizandrin. Tannins, saponins, sterols, triterpenes, alkaloids, anthraquinones, flavonoids, lactones/esters, protein, amino acids and carbohydrates, glycides | C₆H₁₃NO₅, C₁₄H₁ₑNO₅ |
| 77  | *Schouwia thebaica*  | Arecaceae  | Aerial parts |                                                                                      | CCl₄      |
| 78  | *Scoparia dulcis*    | Scrophulariaceae | Whole plant | Alkaloids, flavonoids, phenols, terpenoids, tannins and saponins                     | CCl₄      |
| 79  | *Solanum nigrum* (Manathakkali) | Solanaceae | Fruits, leaves | Carbohydrates, glycosides, alkaloids, phenols, flavonoids and tannins               | C₂H₅NS, CCl₄ |
| 80  | *Strychnos potatorum* Linn. | Loganiaceae | Seed          | Norharmane, akuammidine, Nor-C-fluroiocuraine, ochrolifuanine, Bisnor Dihydro toxiferine, 11-Methoxy-Henningsamine, 11-methoxy-12 hydroxydiabolin and 11-Methoxydiabolin | CCl₄      |
| 81  | *Swertia chirata*    | Gentianaceae | Whole plants | Carbohydrates, glycosides, alkaloids, phenols, flavonoids and tannins               | C₂H₅NS, C₂H₅NO₂ |
| 82  | *Syzygium cuminii L.* | Myrtaceae  | Leaves        | Friedelin, kaempferol, tannins, quercetin, beta-sitosterol, betulinic acid, anthocyanin acid, eugen, ellagic acid, oxalic acid, citric acid, glycolic acid, glucose, fructose, gallic acid, glycine, alanin, leucin, tyrosin | CCl₄      |
| 83  | *Spermacoce hispida* | Rubiaceae  | Seed          | Borreline, B-sitosterol, ursolic acid and isorhamintin                               | CCl₄      |
| 84  | *Taraxacum officinale* | Asteraceae  | Root          | Alkaloids, tannins, flavonoids and phenolic compounds                                | CCl₄      |
| 85  | *Teckomella undulata* | Bignoniaceae | Stem, Bark    | Alkaloids, steroids, volatile oil, fat, tannin, carbohydrate, saponin and flavonoids | C₂H₂O₂ and C₂H₄NO₂ |
| 86  | *Terminalia arjuna* Roxb | Combretaceae | Bark          | Beta-sitosterol, arjunic acid, friedlcar, glucoside, tannins, sugars, sodium, magnessium, aluminium, calcium carbonate | CCl₄      |
| 87  | *Terminalia catappa L.* (Combretaceae) | Combretaceae | Leaves        | Tannins, sugars, sodium, magnesium, aluminium, calcium carbonate                       | CCl₄      |
| 88  | *Thunbergia laurifolia* Linn. | Acanthaceae | Leaves, aerial part | Benzyl alcohol glucosides, Iridoid glucoside, two aliphatic alcohol glucosides and two flavonoid C-glucosides | C₂H₂OH |
| 89  | *Trigonella foenumgraecum* (Venthayam) | Fabaceae | Leaves, seeds | Fibers, flavonoids, polysaccharides, saponins, flavonoids and polysaccharides fixed oils alkaloids | C₂₂H₂₁Br₂NO₃ |
90 Tridax procumbens Lin  
(Avella, Avul, Vettukaaya poondu)  
Asteraceae  
Leaves  
Steroid like saponin, coumarins, alkaloids, amino acids, diterpenes, phenol whereas Flavonoids like tannin, anthocyanin, emodins, proteins, phytosterol, phlobatannin, C6H13NO5

91 Trichosanthes cucumerina L.  
Cucurbitaceae  
Whole plant  
Cucurbitacin B, Cucurbitacin E, Isocucurbitacin B, Isocucurbitacin E, 23,24-Dihydroisocucurbitacin B, 23,24-Dihydrocucurbitacin E, Sterols 2 B-sitosterol Stigmasterol, CCl4

92 Vernonia amygdalina  
Asteraceae  
Leaves  
Alkaloids, flavonoids, glycosides, saponins, tannins, phenols, B-carotenoids, cyanogenic glycosides and steroids, CCl4

93 Vigna unguiculata L. (Karamani in tamili)  
Fabaceae  
Seeds  
Carotene, thiamine, riboflavin, niacin, folic acid, vitamin C, tripsin inhibitors as A2a, A2b, A2c, A2d, A2e; phytohemagglutinin, α-cedrene, 1,8-cineole, hexanal, limonene, nonanal, α-pinene and β-pinane, C8H9NO2

94 Vitis vinifera L. (Thirachai)  
Vitaceae  
Leaves  
Phenolic acids, flavonoids, anthocyanins, proanthocyanidins, sugars, sterols, amino acids and minerals, CCl4

95 Zanthoxylum armatum DC.  
Rutaceae  
Bark  
Nitidine, dihydronitidine, oxynitidine, fagaronine, dihydroyavicine, chelerythrine, phydrochelerythrine, methoxychelerythrine, norchelerythrine, oxyclohexylthrine, decarine and fagaridine, CCl4

of conditions such as scabies, rheumatism, paralysis, asthma and snake-bites, skin disease and ulcer[42]. The plant is rich source of steroids, triterpenes, saponins, flavonoids, alkaloids and tannins[43]. Recently, find the three naphthoquinones and their analogues, named avicequinone-A, avicequinone-B, avicequinone-C and avicequinone-A, avicequinone-B, avicequinone-C respectively[44]. These are compounds isolated from the stem bark and isolated a new flavonoid, 2-[3’-(3”-(hydroxymethyl) oxiran-2”-yl)-2’-methoxy-4’-(methoxyethyl) phenyl]-4Hehromen-4-one from the aerial parts. Hepatotoxicity was induced by C8H9NO2 and this experiment was assessment by biochemical parameters such as AST, Alkaline Phosphatase (ALP), ALT and total bilirubin (serum bilirubin). The in vivo antioxidant such as superoxide dismutase, catalase, Glutathione, vitamin C and E, and thiobarbituric acid reactive substances, and histopathological changes in liver were studied along with C25H22NO10 as standard hepatoprotective agent[45]. Results of this study showed preliminary phytochemical analysis of the ethanolic extract shows the presence of alkaloids, flavonoids, tannins, terpenoids, proteins and steroids. Treatment with plant extract to C8H9NO2 administered rats caused a
significant reduction in the values of AST, ALP, ALT and total bilirubin almost comparable to standard drug C$_{2}$H$_{2}$O$_{10}$. Hepatoprotective activity was confirmed by histopathological assessment of the liver tissue of control and treated animals. In this research, it can be concluded that C$_{2}$H$_{2}$OH extract of leaves possess hepatoprotective effect.

**Anisochilus carnosus (L) Wall.:**

*Anisochilus carnosus* (Lamiaceae family) “karppuravalli” is an annual herb and has been traditionally used for the treatment of gastrointestinal disorders, respiratory disorders, cough, cold and fever. Its popular herbal preparation together with *Ocimum basilicum, Mentha piperita* and *Alpinia galanga* is used against the symptoms of influenza, dermatitis and the slight illness that derives from the bites of bugs. Essential oils have been extracted by hydro distillation from the leaves and have been reported to be antimicrobial in nature. A pharmacological activity of this plant shows anti-inflammatory activity, antiulcer activity, antifungal property and anticancer property. Previously reported that, this plant shows phytochemicals active compounds such as saponins, tannins, flavonoids (apigenin and luteolin), phytosterols, triterpenoids and essential oil components (carvacrol, β-selinene, camphor, α-cis-bergamotene and caryophyllene) etc.. Analysis of leaf and leaf callus extracts was done by qualitative analysis and was used for hepatotoxicity induced by alcohol. This research results revealed that C$_{2}$H$_{2}$OH leaf extract pretreated HepG2-Human liver cancer cell line show 94 % cell viability compared to the standard C$_{25}$H$_{22}$O$_{10}$ pretreated HepG2 cells which showed 81 % cell viability. This plant leaf callus extracts also showed significant hepatoprotective activity where C$_{2}$H$_{2}$OH callus extract pretreated HepG2 cells showed 86 % viability after intoxication with alcohol. Results revealed that HepG2 cell viability percentage is dose dependent. Phytochemical studies revealed the presence of different secondary metabolites in leaf and leaf callus extracts that shows hepatoprotective activities.

**Baliospermum montanum (Willd) Muell. Arg:**

*Baliospermum montanum* (Euphorbiaceae family) “pey-amanakku” is one of the very important plant of Ayurveda being used for millennia as a purgative along with its wide-ranging health benefits and is useful against many more disorders. Danti has been explained in various classics as a major as well as minor ingredient of various formulations used in different diseases. Single-handed information on the external application of usage of Danti is not available. C$_{2}$H$_{5}$OH leaf extract gas chromatography mass spectrometric spectrum showed various phyto-constituents like Olean-12-ene, 3β-methoxy, α-amyrin, lanosterol, Lup-20 (29)-en-3-ol, acetate, betulin etc.. On the other hand, hepatoprotective activity of methanol extract from the roots of *Baliospermum montanum* and its methanol fraction were carried out using C$_{2}$H$_{5}$NS induced liver damage in albino rats. This study was assessed by glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, alkaline phosphatase, total bilirubin, total cholesterol, total protein and albumin in serum. At the same time analyzed histopathology of liver sections confirmed that, pre-treatment with methanol extract and methanol fraction prevented hepatic damage induced by C$_{2}$H$_{5}$NS. It is suggested that, the presence of flavonoids in methanol extract and its methanol fraction may be responsible for hepatoprotective properties. HPTLC profile of flavonoids of bioactive extracts was developed using quercetin-3-O-galactosyl-7-O-rhamnoside as a marker. Methanolic extract of *Baliospermum montanum* has shown strong hepatoprotective activity.

**Centella asiatica L.:**

*Centella asiatica* (Apiaceae family), which is a slender, prostrate, glabrous, perennial creeping herb rooting at the nodes, with simple petiolate, palmately lobed leaves and it has various pharmacological activities like memory enhancing, anti-inflammatory, antioxidant, wound healing, and immune-stimulant, anti-anxiety (anti-hypertensive), anti-stress and anti-epilepsy. Various health benefits of *Centella asiatica* have led to the amplified usage of this plant in food and beverages. It has been extensively used for the treatment of ailments like inflammation, syphilis, mental illness, skin diseases, rheumatism, epilepsy, hysteria, diarrhea, wounds, dehydration and ulcers. Aqueous extract of the plant aerial parts extracted from essential oil. Around 64 volatile compounds were identified from the essential oil p-cymene (35 %) is the predominant compound in the leaf essential oil, such as α-thujene, α-pinene, camphen, γ-2-carene, α-terpene, t-cymene, limonene, 3,8-diene, e-terpinens, linalool, allo-cocimene, 3-non-2-one, menthone, methyl cavaexol, trans myrtenol, bornyl acetate, myrtenyl acetate, α-elemene, bicycloelemens, nonanal, E-caryophyllene, guaiene, B-caryophyllene etc.. The protective effect of *Centella asiatica* is against C$_{8}$H$_{14}$NO$_{2}$ liver injury which may be attributed...
to its hepatoprotective activity.  

**Clitoria ternatea L.:**

*Clitoria ternatea* (Fabaceae family) “Kannikkodi” is a medicinal plant native to tropical equatorial Asia and commonly used in folk medicine to treat various diseases. The leaves and roots are used in the treatment of a number of ailments including body aches, infections, urinogenital disorders, and as an anthelmintic and antitoxin activity to animal stings. The young shoots, leaves, flowers and tender pods are eaten as a vegetable in Kerala (India) and in the Philippines. In Malaysia, the leaves impart a green color to food and the flowers to impart a bright blue color to rice cakes. It’s commonly used in Ayurvedic medicine to treat various types of ailments including memory enhancer, nootropic, anti-stress, anxiolytic, antidepressant, anticonvulsant, tranquilizing and sedative agent. Various secondary metabolites such as polyphenolic flavonoids, anthocyanin glycosides, pentacyclic triterpenoids and phytosterols have been reported from this plant. Flavonoids i.e., kaempherols, quercetin and myricetin and their glycosides were also isolated from this plant. Mass spectral analysis of leaf methanolic extract compounds, such as Butyl-2-methylpropylphthalate, Pentadecanoic acid ME, Decyloctylphthalate, 3-methylhexane, Cyclotetradecane, 2-methylpentane, Decyloctylphthalate, 3-methylhexane, Butyl-2-ethylhexylphthalate, Isopropylbenzene etc., was carried out. Rats treated with *Clitoria ternatea* leaf extracts showed positive results in protecting themselves against damage caused by CCl₄. Interestingly, the treated group with *Clitoria ternatea* extracts was observed to possess a reduced level of enzymes such as AST, ALT and bilirubin compared to a raised level in AST, ALT, and bilirubin in CCl₄-treated group.

**Eclipta alba (Linn):**

The plant *Eclipta alba* (Family: Asteraceae) having important role in the traditional Ayurvedic, “Karislilanganni” Unani systems of holistic health and herbal medicine of the east. The principal constituents of *Eclipta alba* are coumestan derivatives like wedololactone (1.6 %), dimethyl wedelolactone, desmethyl-wedelolactone-7-glucoside and other constituents are eclipitan, β-amyrin, luteolin-7-O-glucoside, hentriacontan, heptacosanol, stigmasterol. All the parts of *Eclipta alba* and chemical constituents are used as anticancer, antileptonic, analgesic, antioxidant, anti-cytotoxic, anti-haemorrhagic, anti-hepatotoxic, antiviral, antibacterial, spasmogenic, hypotensive, hepatoprotective ovicidal, promoter for blackening and growth of hair. Therefore, this plant plays a momentous role in medicinal field and it has promising cosmetic as well as therapeutic application and hence its extraction is essential. Root are analyzed by mass spectral analysis, and exhibit various phyto-constituents such as 2-Thiophenecarbaldehyde, 5-[5-(thien-2-yl)thien-2-yl]-Benzyl-beta-d-glucoside, Octadec-9,12-dienoic acid methyl ester, 2-Propanoic acid, 3-(4-hydroxy-3-methoxyphenyl)-methyl ester, Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester, Dodecanol acid, Benzenepropanoic acid, 4-((1E)-3-Hydroxy-1-propenyl)-2-methoxyphenol, Retino[69]. It’s significantly counteracted CCl₄-induced inhibition of the hepatic microsomal drug metabolizing enzymes. Further, the loss of hepatic is lysosomal acid, phosphatase and alkaline phosphatase by CCl₄. The study shows the hepatoprotective activity.

**Justicia adhatoda (L) Willd.:**

*Justicia adhatoda* (Family: Acanthaceae) with the common name “Adathoda” is a perennial shrub, and mainly consist of quinazoline alkaloids like visicine, vasicinone, vasicol, pregnane along with other minor constituents like adhatonine, vasicolin and vasicinolone[71]. Extracts have been used for the treatment of various diseases and disorders in Ayurveda and tuberculosis[72]. *Justicia adhatoda* leaf extract is a known antioxidant and has also been reported to possess hepatoprotective activity[73]. The present study has been undertaken to explore the hepatoprotective action of isolated vasicinone from the leaves in mice. Preliminary phytochemical analysis shows alkaloids, carbohydrates, glycosides, cardiac glycosides, saponins, hydroxyanthraquinones, phlobatannins, proteins, xanthoprotein, amino acids, steroids, terpenoids, phenols, volatile oil, fatty acid, emodins[72]. *Justicia adhatoda* leaf showed significant hepatoprotective effect at doses of 50 to 100 mg/kg on liver damage.
induced by D-galactosamine in rats[74].

**Phyllanthus emblica** (Linn.):

*Phyllanthus emblica* (Family: Euphorbiaceae). All parts of the plant are used for medicinal purposes; especially the fruits are found having tremendous pharmacological applications. They are used both as a medicine and as a tonic to build up lost vitality and vigor, and it is highly nutritious, important dietary source of vitamin C, amino acids and minerals. In traditional medicine, the fruits are used for the treatment of diarrhea, jaundice and inflammation. Further, they also showed antidiabetic, hypolipidemic, antibacterial, antioxidant, anti-ulcerogenic, hepatoprotective, gastroprotective, and chemopreventive properties[75]. Phenolic components were found out from *Phyllanthus emblica* leaf, flower, fruit by column chromatography and associated with Nuclear Magnetic Resonance (NMR) spectrum. It is acknowledged that gallotannins are the major phenolic constituents of leaf, flower and fruit. The NMR data with the literature led to identification of compounds such as mucic acid 1,4-lactone-5-O-gallate, 2-keto-glucono-lactone, 6-methyl ester[76]. The study also confirms the hepatoprotective and antioxidant activities of leaves of *Phyllanthus emblica*[77].

**Pisonia grandis** R.Br:

*Pisonia grandis* (Family: Nyctaginaceae). Leaves, stems and roots of this species are extensively used by the tribes in the preparation of several folk medicines and is traditionally used as anti-rheumatic and antifungal. It is also pharmacologically studied for its anti-fungal, anti-oxidant, anti-microbial, anti-inflammatory, anti-diabetic, diuretic, analgesic and wound healing properties[78], then phytoconstituents such as protein, carbohydrate, sterols, alkaloids, flavonoids, quinones, fatty acids, tannins, terpenoids, phenols, saponins, glycosides, coumarin, xanthproteic acid etc.,[79] from the *C₂H₂OH* extract. The *C₂H₂OH* aqueous extracts of leaves are screened for its hepatoprotective potential against liver injury induced by *CCl₄*, *C₅H₅NO₂* or *C₂H₅NS* and chronic liver damage induced by *CCl₄* in rats. Pretreatment of animals with the extract reduced inflammation and degenerative changes. Histological examination of liver tissues supported the hepatoprotection by both the extracts and thus the *C₂H₂OH* and aqueous extracts showed significant hepatoprotective activity in *CCl₄* induced acute and chronic liver damage[75].

**Syzygium cumini** (L.) Naval:

*Syzygium cumini* (Family: Myrtaceae), gives the authority of due to the presence of the various phytochemical constituents such as alkaloids, fatty acids, steroids and tannins. Biochemical analysis and histopathology were achieved by collecting the blood samples and liver tissues. The methanol extracts of plant seed shows significantly increase the serum protein and decrease the enzyme level in control and treated groups as compared to that of the *CCl₄* treated group. The hepatic tissues protected by the extract of seeds in both the doses and *C₂H₅NO₂* from *CCl₄* induced stress which indicates by histological examination of liver tissues. It was concluded that extract of seed has hepatoprotective activity[72].

Some studies were carried out for the presence of anti-diabetic, hepatoprotective, anti-inflammatory, antioxidant, anti-ulcers, anti-diarrheal and anti-microbial activities. It contains anthocyanins, glucoside, ellagic acid, isoqueretin, kaemferol and myrecitin[16]. Photochemical analysis of this plant identified gallic acid, cyanidin glycoside, glycoside jambolin, triterpenoids, tannins, gallotannins, essential oils, myricetin, β-sitosterol, myricyl alcohol etc.,[80]. Leaves and seeds from aqueous extracts (LASc, SASc, respectively) as well as their effect in a 2,2 azobis-2-amidinopropane dihydrochloride (AAPH) induced model of oxidative damage in human lymphocytes, in vitro[79].

**CONCLUSION**

This review results exhibit *Syzygium cumini* has protective and immune-modulatory effects on AAPH-induced damage in lymphocytes, assessed by in vitro studies. The protective effect of these indigenous medicinal plant extracts against *CCl₄*, *C₅H₅NO₂*, and *C₂H₅NS* may be related to polyphenolic compounds, terpenoids, alkaloids, coumarines, phytosterols. Polyphenolic compounds such as flavonoids can protect the cells against emptying reduced glutathione via increasing the capability of antioxidant enzymes, and shows antioxidant activity, free radical scavenging and anti-lipoperoxidant agent is helpful for hepatoprotection. Furthermore, these phyto compounds with antioxidant properties can counteract free radicals in the environment and therefore avoid their destructive effects. Terpenoids such as carotenoids with anti-hepatotoxic activity are also known as antioxidants. Ursolic acid is a triterpene, with potential hepatoprotective effects. Therefore, herbal medications should be recommended within the
setting of more finely-conducted clinical trials, in spite of, better training of both patients and physicians about herbal preparations seems necessary.

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Conflict of interest:

The authors report no conflict of interest in this work.

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