Review Article

Hepatoprotective Effect of Indigenous Medicinal Plants: A Review

M. MINNADY, G. JAYAPAL[1], SASIKALA POOCHI, P. NETHAJI[2] AND B. MATHALAIMUTHU*

Department of Zoology, Annamalai University, Annamalai Nagar, Tamil Nadu 608002, [1]Department of Zoology, Poompuhar College (Autonomous), Melaiyur 609107, [2]Department of Chemistry, Annamalai University, Annamalai Nagar, Tamil Nadu 608002, India

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 ($C_8H_9NO_2$), thioacetamide (C_2H_5NS), carbon tetrachloride (CCl_4), silymarin ($C_25H_{22}O_{10}$), ethanol (C_2H_5OH) 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 adhatada, Phyllanthus emblica, Pisonia grandis* and *Syzgium 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 (CCl_4), pyrrolizidine alkaloids, allyl alcohol, Thioacetamide (C_2H_5NS), 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 medicine[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 C_2H_5NS stimulated liver damage[14,15].

HEPATOTOXICITY AGENTS

Several chemicals have been known to induce hepatotoxicity and CCl_4, C_2H_5NS, $C_8H_9NO_2$, C_2H_5OH

***Address for correspondence**
E-mail: bharanitharan2011@gmail.com

Accepted 02 September 2022
Revised 10 March 2022
Received 12 August 2021
Indian J Pharm Sci 2022;84(5):1116-1132

and $C_{25}H_{22}O_{10}$ are used to induce experimental hepatotoxicity in laboratory animals.

CCl_4:

Liver injury due to CCl_4 (fig. 1a) in rats was first reported in 1936 and broadly utilized by so many researchers[16,17]. CCl_4 toxicity depends on dosage and the duration of exposure. In low dose, effects like loss of Ca^{2+} 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 monooxygenases, mainly through the CYP2E1 isoform in the endoplasmic reticulum and mitochondria[19]. Hepatotoxicity is produced by the formation of the trichloromethyl radical (CCl_3) (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 CCl_4[21]. The inhibition of the radical CCl_3 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].

C_2H_5NS:

C_2H_5NS 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 freebie radical derivatives such as C_2H_5NS sulfoxide, 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 C_2H_5NS (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].

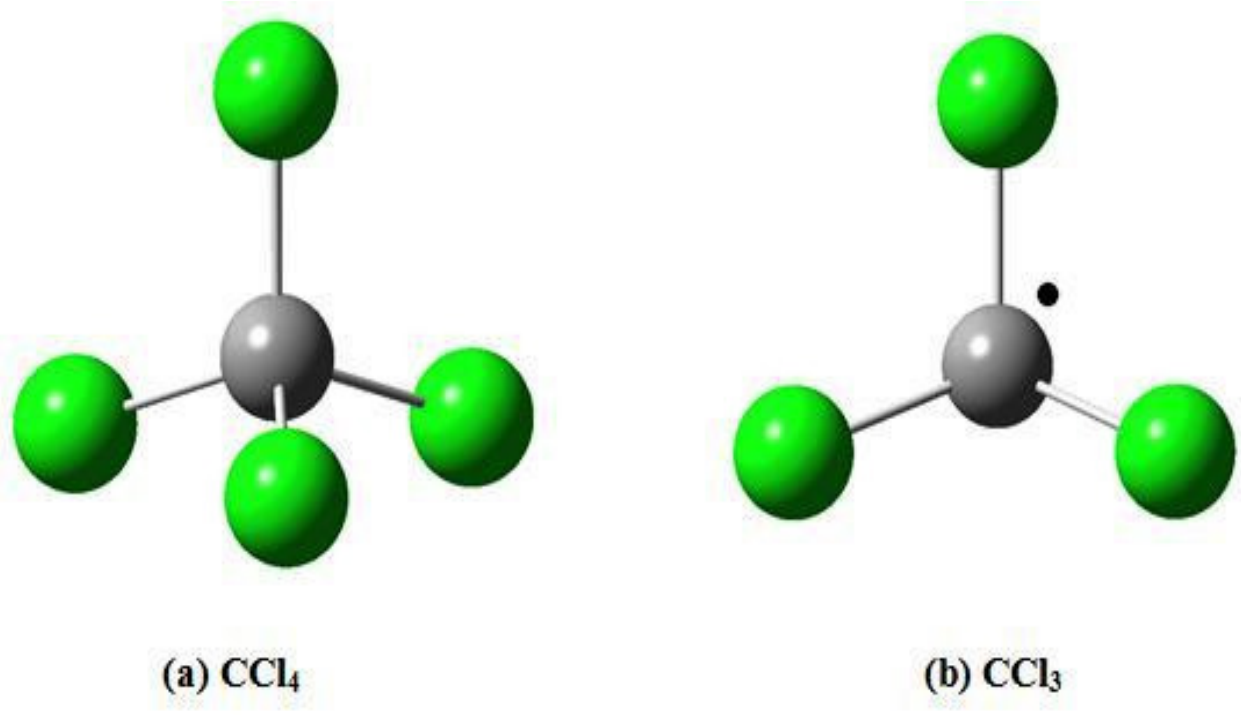

Fig. 1: 3D structures of (a): $CCl_4$and (b): CCl_3

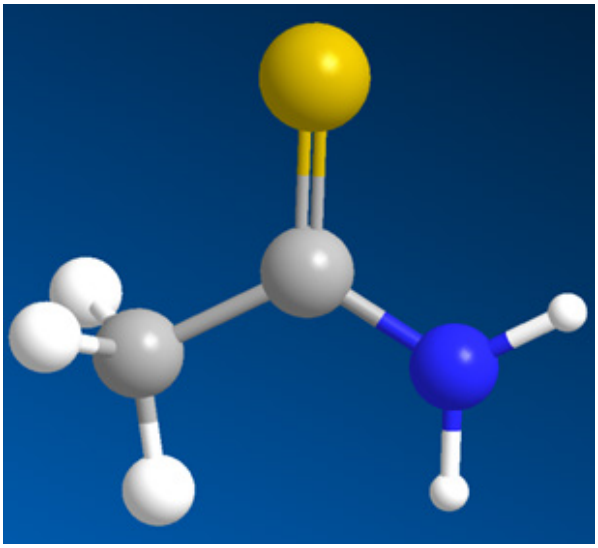

Fig. 2: 3D structure of C_2H_5NS

However, C_2H_5NS 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[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[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[30,31].

$C_8H_9NO_2$:

$C_8H_9NO_2$, (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[5] and is a widely used experimental model of clinical importance as an example of drug-induced liver damage[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 1st 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 2nd 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, 3rd occurs with glucagon depletion in hepatocytes through alcohol intake or malnutrition[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[33].

C_2H_5OH:

The liver is the most susceptible organ to the toxic effects of C_2H_5OH (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[34]. Membrane lipid peroxidation results in the loss of its structure and integrity, elevating serum levels of glutamyl-transpeptidase, a membrane bonding enzyme. C_2H_5OH inhibits glutathione peroxidase; it reduces the activity of catalase and superoxide dismutase[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_2H_5OH or alternatively, they could be a direct effect of acetaldehyde, a product of C_2H_5OH oxidation[35].

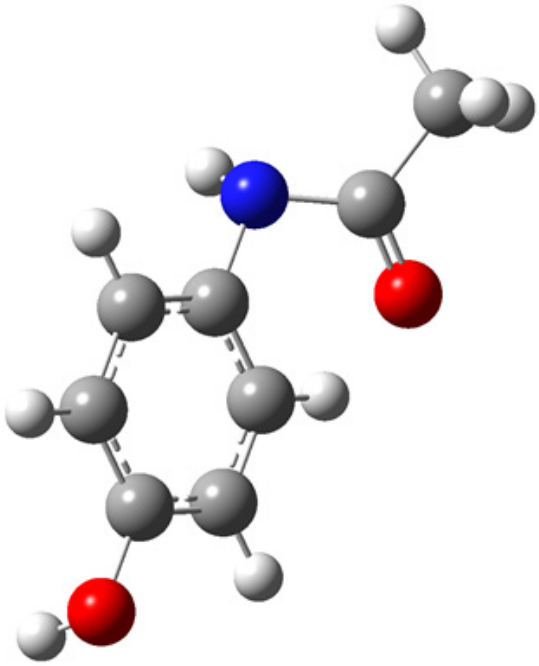

Fig. 3: 3D structure of $C_8H_9NO_2$

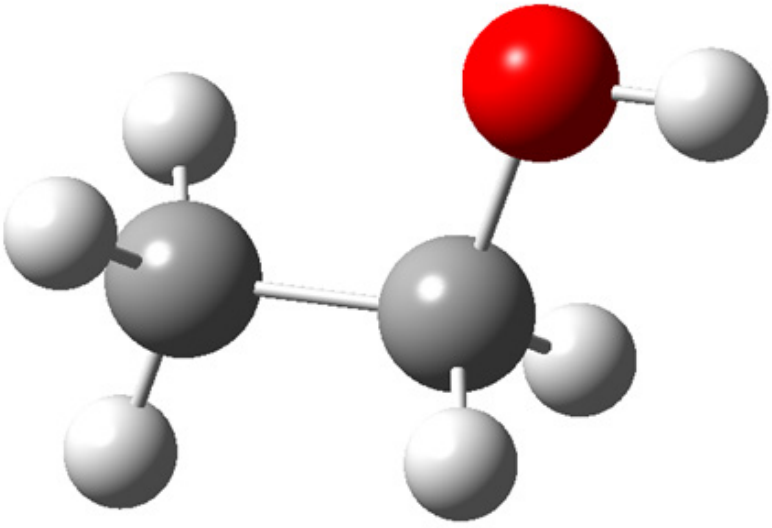

Fig. 4: 3D structure of $C_2H_5OH_2$

$C_{25}H_{22}O_{10}$:

$C_{25}H_{22}O_{10}$ (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, Baliospermum 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	$C_8H_9NO_2$
2	*Agrimonia eupatoria*	Rosaceae	Whole plants	ß-sitosterol, betalain andneoandrographolide	C_2H_5OH
3	*Aerva lanata* Linn (Serupeelai)	Amaranthaceae	Coarse powder plant material	Alkaloids-ß-carboline-1 -propionic acid, 6-methoxy-ß carboline-1-propionic acid, 6-methoxy-ß-carbolin-l-ylpropionic acid (ervolanine) and aervolanine (3-(6-methyoxy-ß-carbolin-1-yl) propionic acid) Flavanoids-Kaempferol, quercetin, isorhamnetin, isorhamnetin 3-O-ß-[4-p-coumaroyl-α-rhamnosyl, galactoside and flavanone glucoside persinol	$C_8H_9NO_2$
4	*Acacia confusa*	Leguminosae	Bark	Flavonoids, phenolic acids, tannins andphenolic diterpenes	CCl_4
5	*Agrimonia eupatoria*	Rosaceae	Whole plants	ß-sitosterol, betalain andneoandrographolide	C_2H_5OH
6	*Aloe barbadensi Mill.* (Kattalai)	Liliaceae	Aerial part	Flavanoids, hydroxyanthraquinones and coumarin	CCl_4
7	*Alchornea cordifolia*	Euphorbiaceae	Leaves	Saponins, alkaloids, carbohydrates, reducing sugar, tannins and flavonoids	$C_8H_9NO_2$
8	*Andrographis paniculata*(Tamil name-Nilavembu)	Acanthaceae	Leaf, aerial parts	Andrographolide, bicyclic diterpene, lactone, kalmegh, andrograholide	$C_8H_9NO_2$
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	CCl_4
10	*Artemisia sacrorum* Ledeb.	Compositae	Aerial parts	1,8-cineole, chrysanthenone, chrysanthenol (and its acetate), α/ß-thujones and camphor	$C_8H_9NO_2$

11	*Astragalus polysaccharides*	Magnoliaceae	Dried fruits	Flavonoids, non-protein, amino acid, saponins, alkaloids, nitro chemically compounds, mucilage, sterols, proline content and phenolics	CCl_4
12	*Asteracantha longifolia* L.(Neermulli)	Acanthaceae	Leaved axil, flower, root, seed	Andrographolide	$C_6H_{13}NO_5$
13	*Azadirachta indica* (Vembu)	Meliaceae	Whole parts	Azadirachtin, margolone, mono-, di-, sesqui- and triterpenoids, coumarins, chromones, lignans, flavonoids and other phenolics	$C_8H_9NO_2$
14	*Baliospermum montanum* (Tamil name-Nakatanti)	Euphorbiaceae	Root	Alkaloids, phenols, carbohydrates, tannins, steroids, saponins, flavonoids, cardiac glycosides, proteins, terpenoids, resinsand glycosides	$C_8H_9NO_2$
15	*Byrsocarpus coccineus* Schum	Connaraceae	Leaf	Alkaloids, tannins, cardiac glycosides, steroids, terpenoids, flavonoids, anthraquinones, phlobatannins, reducing sugars and saponins	CCl_4
16	*Bauhinia variegate* L.	Leguminosae	Stem bark	Terpenoids, flavonoids, tannins, saponins, reducing sugars, steroids and cardiac glycosides	CCl_4
17	*Cassia tora* L. (Thangarai)	Caesalpiniaceae	Leaves, seeds	Alkaloids, steroids and phlobatannins, phenolics and flavonoids, saponins and cardiac glycosides and tannins	CCl_4
18	*Citrus limon* L. Burm. (Elumichai)	Rutaceae	Fruits	Coumarins, flavonoids, carotenes, terpenes and linalool	CCl_4
19	*Cleome viscose* Linn	Capparidaceae	Leaf powder	Alkaloids, flavonoids and fatty acids are the major active constituents of this genus, six main flavonoid gycosides such as kaempferol, chrysoeriol, isorhamnetin, chrysoeriol-7-O-xylosoid, kaempferol-3-galactorhamnoside and isorhamnetin 3-O-ß-dapio furanosyl and ß-D galactopyranoside	$C_8H_9NO_2$
20	*Curcuma longa*	Zingiberaceae	Rhizome	Curcumin, turmerone, monoterpenes, 5 % curcuminoids, minerals, carotene and vitamin C	$C_8H_9NO_2$, $C_{14}H_{11}Cl_2NO_2$
21	*Chamomile capitula*	Compositae	Whole parts	α-bisabolol, α-bisabolol oxide A and B, chamazulene, sesquiterpenes; coumarins: umbelliferone; flavonoids: luteolin, apigenin, quercetin and spiroethers: en-yn dicycloether	$C_8H_9NO_2$
22	*Cuscuta reflexa* Roxb	Cuscutaceae	Whole plant	Scoparone, melanettin, quercetin hyperoside, luteolin, dulcitol, luteolin and glycoside	$C_8H_9NO_2$
23	*Cassia occidentalis*	Caesalpinaceae	Whole plant	Alkaloids, aaponins, carbohydrates, glycosides, fixed oils and fats, aminoacids, flavanoids, anthraquinones, tannins and phenolic compounds	$C_8H_9NO_2$
24	*Capparis spinosa*	Capparidaceae	Root, bark	Isorhamnitine-3-O rutinoside, 1 tetradecanol, p-hydroxybenzaldehyde, 6,10,14-trimethyl-2-pentadecanone, ursolic acid, glycerol monotetracostanoate, 4-coumaric acid, nicotinamide, methyl hexadecanoate, sitosterol, sitosterylglucoside, cadabicine, octadecanoic acid, rutin and stachydrine	CCl_4
25	*Clerodendrum inerme*	Verbenaceae	Leaves	Phenylpropanoid and phenylethanoid glycosides, flavonoids, diterpenoids and iridoids	CCl_4

26	*Decalepis hamiltonii* Wight.	Asclepiadaceae	Root	4-Omethylresorcylaldehyde, benzyl alcohol, ß-caryophyllene and α-atlantone. Aromatic aldehydes, monoterpene, hydrocarbons, alcohols and ketones, ß-phellandrene and trans-anethole	CCl_4
27	*Diospyros malabarica* Kostel.	Ebenaceae	Bark	Tannins, Triterpenoid compounds such as α-amyrin, uvaol, ursolic acid, 19α-hydroxyursolic acid and 19α, 24-dihydroxyursolic acid	CCl_4
28	*Diplotaxis acris* Boiss.	Compositae	Seeds	Tannins, saponins, sterols and/or triterpenes, alkaloids, anthraquinones, flavonoids, lactones/esters, protein and/or amino acids and carbohydrates and/or glycosides	CCl_4
29	*Equisetum arvense*	Equisetaceae	Aerial parts	Phenolic petrosins, onitin and onitin-9-O-glucoside, flavonoids, apigenin, luteolin, kaempferol-3-O-glucoside and quercetin-3-O-glucoside	CCl_4
30	*Embelia ribes*	Myrsinaceae	Fruits	Reducing sugars, non-reducing polysaccharides, rides, gums, mucilage, proteins, amino acids, fats and oils, steroids, glycosides, saponin, flavonoids, alkaloids, tannins and volatile oil	$C_8H_9NO_2$
31	*Garcinia mangostana*	Clusiaceae	Whole plant	Methylparaben, methyl 3,4,5-trihydroxybenzoate, parvifoliol A1, methyl 2,3-dihydroxybenzoate, 4-hydroxybenzoic acid, epicatechin and xanthone, mangostin	$C_8H_9NO_2$
32	*Gundelia tourenfortii*	Asteraceae	Fresh edible stalk	Steroid and triterpenoids, phenolic and tannins, flavonoids, saponin, alkaloid, anthraquinone, glycoside and protein	CCl_4
33	*Glycyrrhiza glabra L.*	Leguminosae	Glycyrrhizin from root	Saponin, flavonoids, alkaloids, steroids, terpenoids, tannins and glycosides, carbohydrates, proteins, phlobatannins and phenolic compounds	CCl_4
34	*Grewia tiliaefolia* Vahl.	Tiliaceae	γ-lactones from stem bark	Triterpenoids, steroids, glycosides, flavones, lignanes, phenolics, alkaloids, lactones and organic acids	CCl_4
35	*Halenia elliptica*	Gentianaceae	Whole plant	Xanthones, xanthone glycosides, chromones flavonoids, secoiridoid glycosides, triterpenoid alkaloids	CCl_4
36	*Hygrophila auriculata* Heine.	Acanthaceae	Root	Seed contain yellow colour oil, diastase, lipase, protease, salts of potassium and mucilage	CCl_4
37	*Indigophora tinctorea* (Avuri)	Fabaceae	Whole plant	Inorganic salts of nitrogen, phosphoric acid, lime, potash along with apigenin, kaempferol, luteolin, quercetin, seed-galactomannan, galactoss, mannose	$C_8H_9NO_2$
38	Justicia simplex D. Don.	Acanthaceae	Whole plant	Alkaloids, proteins, flavonoids, amino acids, tannins, carbohydrates, saponins, terpenoid and steroids	CCl_4
39	*Juncus subulatus*	Juncaceae	Powdered tubers	Flavonoids, coumarines, terpenes, stilbenes, sterols, phenolic acids, carotenes, phenanthrenes derivatives.	$C_8H_9NO_2$
40	*Kyllinga nemoralis* L.	Cyperaceae	Rhizome	Alkaloids, flavonoids, carbohydrates, phenols, tannins and steroids	CCl_4
41	*Kalanchoe pinnata Pers* (Runa kalli)	Crassulaceae	Leaves	Alkaloids, phenols, flavonoids, tannins, anthocyanins, glycosides, bufadienolides, saponins, coumarins, sitosterols, quinines, carotenoids, tocopherol and lectins	CCl_4

42	*Kigelia africana*	Bignoniaceae	Leaves	Flavanoids, steroidal saponins, napthoquinones and volatile constituents	$C_8H_9NO_2$
43	*Laggera alata* D. Don	Sch.-Bip.	Whole plant	Triterpenes, flavonoids, alkaloids, polyphenols, sterols and saponins	CCl_4
44	*Ligustrum robustum* Roxb.	Oleaceae	Leaves	Terpenoids, saponins, polyphenols (especially flavonoids), glycosides and many other compounds	CCl_4
45	*Luffa echinata*	Cucurbitaceae	Fruits	Lucosides C, E, F, H, a mixture of alpha-spinasterol, alpha-spnisteryl glucoside, stigmasteryl-beta-D-glucoside and methyl ester	CCl_4
46	*Lactuca sativa*	Asteraceae	Whole plants	Ursolic acid , stigmasterol, sitosterol, b-sitosterol galactoside, herniarin and 2, 4, 6-trihydroxyethylbenzoate	CCl_4
47	*Macrotyloma uniflorum*	Fabaceae	Seeds	Flavanoids and tannins	$C_6H_{13}NO_5$, $C_8H_9NO_2$, $C_{25}H_{22}O_{10}$
48	*Moringa oleifera* Lam. (Murungai maram)	Moringeaceae	Seed	Hydrocarbons, hexacosane, pentacosane, heptacosane, pentacosane hexacosane, (E)-phytol, thymol, hexanoic acid, acetic acid, nonacosane, 1,2,4-trimethyl-benzene	CCl_4
49	*Myrtus communis* Linn	Myrtaceae	Leaves	Flavonoids, terpenoids, steroids	$C_8H_9NO_2$
50	*Momordica dioica*	Cucurbitaceae	Leaves	Saponins, tannins, flavonoids, steroids, triterpenes, coumarins, quinones, organic acids and alkaloids	CCl_4
51	*Nelumbo nucifera* Gaertn.	Nelumbonaceae	Leaves	Glucose, tannin, fat, resin, metarbin, alkaloid nelumbine	CCl_4
52	*Ocimum snctum* (Thulasi)	Lamiaceae	Leaves	Alkaloids, tannin, saponin, steroid phlobatannin, terpenoid, flavonoid, cardiac, glyceride	$C_8H_9NO_2$
53	*Ptrospermum acerifolium*	Sterculiaceae	Leaves	Alkaloid, tannin, saponin, flavonoid, cardiacglycosides, sterols, anthroquinone, glycosides, carbohydrates and protein	CCl_4
54	*Petroselinum Crispum* (Mill.)	Umbelliferae	Leaves	Alkaloid, carbohydrate, phenolic compound, tannins, flavonoids, proteins, amino acids and saponins	CCl_4
55	*Pergularia daemia* Forsk.	Asclepiadaceae	Aerial part	Cardenolides, alkaloid, saponins and steroidal compounds, fixed oil, volatile oil, resin, alkaloid, triterpenoid, carissol, carissic acid and ursolic acid	CCl_4
56	*Phyllanthus niruri* L.	Euphorbiaceae	Aerial parts	Phyllanthin, niranthin, hypophyllanthin, alkaloid, lignas, vitamin-C, quercetin, astrogaln, querscitrin, rutin, glucoflavon, linoleic, linolenic, acidCoumarins, tannins and polyphenols, gallic acid, ellagic acid, brevifolin, carboxylic acid, ethyl brevifolin, carboxylate, methyl brevifolin, carboxylate, lizuka, geraniin, corilagin, phyllanthusiin D amariin, amariinic acid, elaeocarpusin, geraniinic acid B, repandusinic acid, Amarulone, Furosin, 1,6-Digalloyl glucopyranoside, catechin, Epicatechin, gallocatechin,epigallocatechin, epicatechin 3-o-gallate, epigallocatechin 3-o-gallate	$C_6H_{13}NO_5$, $C_8H_9NO_2$
57	*Plantago major* L.	Plantaginaceae	Seeds	Total phenol, flavonoid and tannin	CCl_4
58	*Platycodon grandiflorum* A. DC.	Campanulaceae	Saponins derived from root	Steroidal saponins, flavonoids, polyacetylenes, sterols, phenolics and other bioactive compounds	CCl_4
59	*Pracparatum mungo*		Fermented product	Essential oils, saponins, carotenoids, lectins, vitamins, fiber and fatty acids	CCl_4

60	*Pterocarpus marsupium* Roxb.	Papilionaceae	Stem bark	Protein, pentosan, mucilage, pterosupin, pseudobaptigenin, liquiritigenin, garbanzol, beta-cudesmol, pterostil-bene, marsupol, carpusin, proterol, marrsupinol, parsupin, oleanolic, tannins and ksinotanic acid, quercetin, kaempferol, epicatechin, and rutin, phytol, 1H-indene, 1-ethylideneoctahydro-7 a-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	CCl_4
61	*Punica granatum* Linn. (Maathulai)	Punicaceae	Whole plant	Triterpenoids, steroids, glycosides, saponins, alkaloids, flavonoids, tannins, carbohydrates and vitamin C	CCl_4
62	*Plumbago zeylanica*	Plumbaginaceae		Volatile oils, chitranone, alpha and beta amyrin, lupeol, taraxasterol, fructose, glucose, invertase, protease, chloroplumbagin, droserone, ellipticine, zeylanone, zeylone, meritone, catechol, tannin, amino acids, plumbagic acid	$C_8H_9NO_2$
63	*Physalis minima*	Solanaceae	Whole plant	Alkaloids, anthraquinones, flavonoids, cardiac glycosides, phenols, quinones, reducing sugars, saponins, steroids, starch, tannins and terpenoids	$C_8H_9NO_2$
64	*Pseudarthria vicida*	Fabacea	Roots	Leucopelargonidin	$C_8H_9NO_2$
65	*Phyllanthus emblica* (Perunelli)	Euphorbiaceae	Whole plant	Protein, fats, fibres, carbohyderates, vitamin-C, nicotinic acid, tannins, gallic acid, ellagic acid, flavin and glucose, linolenic acid, oleic acid	$C_8H_9NO_2$
66	*Quercus aliena* Blum.	Fagaceae	Whole plant	Tannins, polyphenols, abscisic acid and indoleacetic acid	CCl_4
67	*Rhodococcum vitis* Idaea Linn	Ericaceae	Leaves	Amyrin acetate, mixture of amyrins, ß-sitosterol, scopoletin, iridoids, isoplumericin, plumieride, plumieride coumarate, plumieride coumarate glucoside	$C_6H_{13}NO_5$
68	*Rhoicissus tridentate* Wild.	Vitaceae	Root	Phenols, alkaloids, flavonoids, tannins and saponins	CCl_4
69	*Rheum emodi* Wall (Reval senni)	Polygonaceae	Whole plants	Anthraquinones, anthrones, stilbenes, oxanthrone ethers and esters, flavonoids, lignans, phenols, carbohydrates, oxalic acids, anthraquinones includes rhein, chrysophanol, Aloe-emodin, emodin, physcion (emodin monomethyl ether), chrysophanein and emodin glycoside. Stilbene includes picetannol, resveratrol and their glycosides	CCl_4
70	*Ricinus communis* (Aamanakku)	Euphorbiaceae	Leaves	Steroids, saponins, alkaloids, flavonoids and glycosides. Dried leaves: Alkaloids, ricinine and N demethylricinine, flavones glycosides, kaempferol-3-O, kaempferol-3-O-ß-D-glucopyranoside, quercetinxylopyranoside, quercetin-3-O-ß-D-lucopyranoside, kaempferol, O-ß-rutinoside, quercetin-3-O-ß-monoterpenoids, gallic acid, quercetin, gentisicacid, rutin, epicatechin, ellagic acid, indole-3-acetic acid, ricinoleic,isoricinoleic, stearic anddihydroxystearic acids and also lipases and aricinine	CCl_4

71	*Saururus chinensis*	Saururaceae	Whole plant	Isoflavons, saponins, phytosterols and phenols	CCl_4
72	*Spondias pinnata*	Anacardiaceae	Stem heartwood	Flavonoids, tannins, saponins and terpenoids, essential oils from the pulp yielded carboxylic acids and esters, alcohols, aromatic hydrocarbons, 9, 12, 15-octadecatrien-1-ol, hexadecanoic acid, furfural, 24-methylene cycloartanone, stigma-4en-3one, lignoceric acid, ß-sitosterol and its ß-D-glucoside, ß-amyrin, oeanolic acid, glycine, cystine, Serine, alanine and leucine, lignoceric acid, ß-sitosterol, glucoside	CCl_4
73	*Sarcostemma brevistigma*	Asclepiadaceae	Stem	Bergenin, brevine, brevinine, sarcogenin, sarcobiose and flavonoids	CCl_4
74	*Sesbania grandiflora* L.	Fabaceae	Whole plant	Sterols, saponins, and tannins	C_2H_5NS and $C_{13}H_{23}ClN_4O_3S$
75	*Sesbania sesban* Mers	Fabaceae	Leaf, Bark, Seed	Alkaloids, carbohydrates, protein, phytosterol, flavonoids, fixed oil cholesterol, campesterol, galactomannan, D-galactopyranoside	C_2H_5NS
76	*Schisandra chinensis*	Schisandraceae	Leaves	Lignans, schizandrin, deoxyschizandrin.	$C_6H_{13}NO_5$
77	*Schouwia thebaica*	Arecaceae	Aerial parts	Tannins, saponins, sterols, triterpenes, alkaloids, anthraquinones, flavonoids, lactones/esters, protein, amino acids and carbohydrates, glycosides	CCl_4
78	*Scoparia dulcis*	Scrophulariaceae	Whole plant	Alkaloids, flavonoids, phenols, terpenoids, tannins and saponins	CCl_4
79	*Solanum nigrum* (Manathakkali)	Solanaceae	Fruits, leaves	Steroidal components, withanolides,Flavonoids, terpenoids	C_2H_5NS, CCl_4
80	*Strychnos potatorum* Linn.	Loganiaceae	Seed	Norharmane, akuammidine, Nor-C-fluroiocuraine, ochrolifuanine, Bis nor Dihydro toxiferine, 11-Methoxy-Henningsamine, 11-methoxy-12 hydroxydiabolin and 11-Methoxydiabolin	CCl_4
81	*Swertia chirata*	Gentianaceae	Whole plants	Carbohydrates, glycosides, alkaloids, phenols, flavonoids and tannins	$C_6H_{13}NO_5$, $C_8H_9NO_2$
82	*Syzygium cumini* L.	Myrtaceae	Leaves	Friedelin, kaempferol, tannins, quercetin, beta-sitosterol, betullinic acid, anthocyanin acid, eugin, ellagic acid, oxalic acid, citric acid, glycolic acid, glucose, fructose, gallic acid, glycine, alanin, leucin, tyrosin	CCl_4
83	*Spermacoce hispida*	Rubiaceae	Seed	Borreline, ß-sitosterol, ursolic acid and isorhamntin	CCl_4
84	*Taraxacum officinale*	Asteraceae	Root	Alkaloids, tannins, flavonoids and phenolic compounds	CCl_4
85	*Tecomella undulata*	Bignoniaceae	Stem, Bark	Alkaloids, steroids, volatile oil, fat, tannin, carbohydrate, saponin and flavonoids	C_2H_5OH and $C_8H_9NO_2$
86	*Terminalia arjuna* Roxb	Combretaceae	Bark	Beta-sitosterol, arjunic acid, friedlene, glucoside, tannins, sugars, sodium, magnessium, aluminium, calcium carbonate	CCl_4
87	*Terminalia catappa* L. (Combretaceae)	Combretaceae	Leaves	Tannins, sugars, sodium, magnesium, aluminium, calcium carbonate	CCl_4
88	*Thunbergia laurifolia* Linn.	Acanthaceae	Leaves, aerial part	Benzyl alcohol glucosides, Iridoid glucoside, two aliphatic alcohol glucosides and two flavonoid C-glucosides	C_2H_5OH
89	*Trigonellafoenumgraecum* (Venthayam)	Fabaceae	Leaves, seeds	Fibers, flavonoids, polysaccharides, saponins, flavonoids and polysaccharides fixed oils alkaloids	$C_{22}H_{19}Br_2NO_3$

90	*Tridax procumbens Lin* (Vettukaaya poondu)	Asteraceae	Leaves	Steroid like saponin, coumarins, alkaloids, amino acids, diterpenes, phenol whereas Flavonoids like tannin, anthocyanin, emodins, proteins, phytosterol, phlobatannin,	$C_6H_{13}NO_5$
91	*Trichosanthes cucumerina* L.	Cucurbitaceae	Whole plant	Cucurbitacin B, Cucurbitacin E, Isocucurbitacin B, 23,24-Dihydroisocucurbitacin B, 23,24-Dihydrocucurbitacin E, Sterols 2 ß-sitosterol Stigmasterol	CCl_4
92	*Vernonia amygdalina*	Astereaceae	Leaves	Alkaloids, flavonoids, glycosides, saponins, tannins, phenols, ß-carotenoids, cyanogenic glycosides and steroids	CCl_4
93	*Vigna unguiculata* L. Walp (Karamani in tamil)	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 ß-pinane.	$C_8H_9NO_2$
94	*Vitis vinifera* L. (Thirachai)	Vitaceae	Leaves	Phenolic acids, flavonoids, anthocyanins, proanthocyanidins, sugars, sterols, amino acids and minerals	CCl_4
95	*Vitex trifolia* (Moovilai nochi)	Verbenaceae	Leaves	Alkaloids, saponin, tannin, phenols, terpenoids, flavonoids, steroids	CCl_4
96	*Wedelia calendulacea*	Asteraceae	Whole plant	Flavonoids, wedelolactone	$C_6H_{13}NO_5$
97	*Woodfordia fruticosa* Kurz	Lythraceae	Flowers	Malvidin, pentose, glycosides, quercetin, Kaempferol-3-Glycoside, hecogenin, carotene, carbohydrates, insulin, 3 mannitol, lawsone, aspartic acid, protein, riboflavin, citric acid, punicaline, estrone	CCl_4
98	*Xylopia aethiopica*	Annonaceae	Fruit	Mono and sesqui terpenes, a-pinene, myrcene, p-cymene, limonene, linalool, terpinen-4-ol, R-terpineol and 1,8-cineole are the most predominant.	$C_8H_9NO_2$
99	*Zanthoxylum armatum* DC.	Rutaceae	Bark	Nitidine, dihydronitidine, oxynitidine, fagaronine, dihydroavicine, chelerythrine, ihydrochelerythrine, methoxychelerythrine, norchelerythrine, oxychelerythrine, decarine and fagaridine), furoquinolines carbazoles , aporphines , canthinones, acridones and aromatic and aliphatic amides.	CCl_4
100	*Zingiber officinale Ros*. (Inchi)	Zingiberaceae	Rhizome	Fibres, proteins, starch, carbohydrates, resin, glutamine, thrionin, free aminoacid, zingiberol, zingiberin, glutamic acid, aspartic acid	$C_8H_9NO_2$
101	*Ziziphus mauritiana* L. (Ilanthai)	Rhamnaceae	Leaves, fruits, bark	Sugars, mucilage	CCl_4

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 avicenol-A, avicenol-B, avicenol-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'-(methoxymethyl) phenyl]-4Hchromen-4-one from the aerial parts. Hepatotoxicity was induced by $C_8H_9NO_2$ 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 $C_{25}H_{22}O_{10}$ 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 $C_8H_9NO_2$ administered rats caused a

significant reduction in the values of AST, ALP, ALT and total bilirubin almost comparable to standard drug $C_{25}H_{22}O_{10}$. 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_2H_5OH extract of leaves possess hepatoprotective effect[46].

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

Anisochilus carnosus (Lamiaceae family) "karppura-valli" is an annual herb and has been traditionally used for the treatment of gastrointestinal disorders, respiratory disorders, cough, cold and fever[47]. 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[48]. Essential oils have been extracted by hydro distillation from the leaves and have been reported to be antimicrobial in nature[49]. A pharmacological activity of this plant shows anti-inflammatory activity[50], antiulcer activity[51], antifungal property[52] and anticancer property[53]. 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.,[54]. 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_2H_5OH 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_2H_5OH 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 hepetoprotective activities[55].

***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[56]. C_2H_5OH 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.,[57]. On the other hand, hepatoprotective activity of methanol extract from the roots of *Baliospermum montanum* and its methanol fraction were carried out using C_2H_5NS 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_2H_5NS. 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 bio-active extracts was developed using quercetin-3-O-galactosyl-7-O-rhamnoside as a marker. Methanolic extract of *Baliospermum montanum* has shown strong hepatoprotective activity[58].

***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[59]. 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[60]. 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, p-menth, 3,8-diene, c-terpinens, linalool, allo-ocimene, 3-non-2-one, menthone, methyl cavacrol, trans myrtenol, bornyl acetate, myrtenyl acetate, α-elemene, bicyoloelemens, nonanal, E-caryophyllene, guaiene, B-caryophyllene etc.,[61]. The protective effect of *Centella asiatica* is against $C_8H_9NO_2$ liver injury which may be attributed

to its hepatoprotective activity[62].

Clitoria ternatea L.:

Clitoria ternatea (Fabaceae family) "Kannikkodi" is a medicinal plant native to tropical equatorial Asia is commonly used in folk medicine to treat various diseases[63]. 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 antidote 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, notropic, 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. Flavonoils i.e., kaempherols, quercetin and myricetin and their glycosides were also isolated from this plant[64]. 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.,[65] was carried out. Rats treated with *Clitoria ternatea* leaf extracts showed positive results in protecting themselves against damage caused by $C_8H_9NO_2$. 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 $C_8H_9NO_2$-treated group[66].

Eclipta alba (Linn):

The plant *Eclipta alba* (Family: Asteraceae) having important role in the traditional Ayurvedic, "Karisilanganni" Unani systems of holistic health and herbal medicine of the east, have reported to possess Hepatoprotective, antimicrobial, anti-inflammatory, analgesic, immune modulatory, antiviral and promoter for blackening and growth of hair. Important source of chemicals is wedelolactone, dimethyl wedelolactone exhibit antihepatotoxic activities. The traditional knowledge with its holistic and systematic approach supported through experimental base can serve as an innovative and powerful discovery of natural 5α-reductase inhibitor[67]. *Eclipta alba* having important role in the traditional Ayurvedic and 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 ecliptal, ß-amyrin, luteolin-7-O-glucoside, hentriacontanol, heptacosanol, stigmasterol. All the parts of *Eclipta alba* and chemical constituents are used as anticancer, anti-leprotic, analgesic, antioxidant, anti-cytotoxic, anti-haemorrhagic, anti-hepatotoxic, antiviral, antibacterial, spasmogenic, hypotensive, hepatoprotective ovicidal, promoter for blackening and growth of hair[68]. 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, Octadeca-9,12-dienoic acid methyl ester, 2-Propenoic acid, 3-(4-hydroxy-3- methoxyphenyl)-,methyl ester, Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester, Dodecanoic acid, Benzenepropanoic acid, 4-((1E)-3-Hydroxy-1-propenyl)-2-methoxyphenol, Retinol[69]. It's significantly counteracted CCl_4-induced inhibition of the hepatic microsomal drug metabolizing enzymes. Further, the loss of hepatic is lysosomal acid, phosphatase and alkaline phosphatase by CCl_4. The study shows the hepatoprotective activity[70].

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, vasicinol 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[52]. *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, antiulcerogenic, hepatoprotective, gastroprotective, and chemopreventive properties[75]. Phenolic components were find 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, flavanoids, quinones, fatty acids, tannins, terpenoids, phenols, saponins, glycosides, coumarin, xanthoproteic acid etc.,[79] from the C_2H_5OH extract. The C_2H_5OH and aqueous extracts of leaves are screened for its hepatoprotective potential against liver injury induced by CC_{l4}, $C_8H_9NO_2$ or C_2H_5NS and chronic liver damage induced by CCl_4 in rats. Pretreatment of animals with the extract reduced inflammation and degenerative changes. Histological examination of liver tissues supported the hapatoprotection by both the extracts and thus the C_2H_5OH and aqueous extracts showed significant hepatoprotective activity in CCl_4 induced acute and chronic liver damage[75].

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

Syzgium 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 CCl_4 treated group. The hepatic tissues protected by the extract of seeds in both the doses and $C_{25}H_{22}O_{10}$ from CCl_4 induced stress which indicates by histological examination of liver tissues. It was concluded that extract of seed has hepatoprotective activity[52].

Some studies were carries 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, isoquercetin, kaemferol and myrecetin[16]. Photochemical analysis of this plant identified gallic acid, cyanidin glycoside, glycoside jambolin, triterpenoids, tannins, gallotanins, 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 *Syzgium 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 $CC1_4$, $C_8H_9NO_2$, and C_2H_5NS 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 phytocompounds 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.

Acknowledgments:

The authors are would like to acknowledge the help and support stretched by the Department of Zoology, Annamalai University, Chidambaram in Tamil Nadu, India.

Conflict of interest:

The authors report no conflict of interest in this work.

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