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A REVIEW ON HEPATOPROTECTIVE ACTIVITY

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ABSTRACT: Liver, the largest gland functioning as an organ of storage, manufacturing and biotransformation is a vulnerable target for injury. Chronic alcohol consumption, exposure to toxic chemicals and certain drugs like paracetamol, tetracycline, antitubercular drugs, chemotherapeutic agents, NSAIDS, damage the liver cells (hepatocytes) in long run. Drug induced liver injury is a major health problem, the manifestations of which are highly variable, ranging from asymptomatic elevation of liver enzymes to fulminant liver failure. Modern medicine has provided us many drugs that alleviate liver diseases but compared to it herbal medicine is preferred because the latter is cost effective and considered to be a safe approach for treatment with minimal side effects. Through the decades many scientists, researchers have reported hepatoprotective activity of many medicinal plants mostly in the form of plant extracts. The present review is aimed at compiling data on different medicinal plants with hepatoprotective activity on various models of hepatotoxicity.

INTRODUCTION: The Liver is the largest gland in a human body, situated in the right side of upper abdominal cavity. The cells of the liver called hepatocytes plays vital functions like;

1. Synthesis of proteins, biles,
2. Stores glycogen, vitamins, iron,
3. Metabolises toxic chemicals and drugs.

Drug metabolism/biotransformation is a process of detoxification in which a substance is chemically modified into a less toxic form under the influence of enzymatic system.

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The capacity of the liver to carry out the several oxidative metabolisms is associated with the high cellular content of cytochrome P450[1]. As liver being the central organ of metabolism it is highly vulnerable target for injury from drugs and chemicals, the manifestations of which are highly variable, ranging from asymptomatic elevation of liver enzymes to fulminant hepatic failure [2].

Herbal medicine: Modern medicines have a little to offer for alleviation of hepatic diseases and it is chiefly the plant based preparations which are employed for their treatment of liver disorders[3]. Herbal medicines are the most lucrative form of traditional medicine on which about 80% of the population depends (WHO traditional medicine facts sheet no 134. Dec 2008). These have gained importance and popularity in recent years because they are easily available, safe, efficient and cost effective.

In India, more than 87 plants are used in 33 patented & proprietary multi-ingredient plant formulations & about 40 polyherbal commercial formulations reputed to have hepatoprotective action are being used. It has been reported that about 160 phytoconstituents from 101 medicinal plants have hepatoprotective activity [4].

Many herbs have been used to alleviate various liver diseases, of which the most popular ones include Silymarin from *Silybum marianum, andrographolide* and neoandrographolide from *Andrographis paniculata*, curcumin from *Curcuma longa*, picroside and kutkoside from *Picrorrhiza kurroa*, phyllanthin and hypophyllanthin from *Phyllanthus niruri*, glycyrrhizin from *Glycyrrhiza glabra*, etc. [5].

Hepatotoxins and their mechanism of hepatotoxicity: In this review, the authors mainly concentrated on hepatotoxins like Carbon tetrachloride, Paracetamol, D-Galactosamine and Thioacetamide.

1. **Carbon tetrachloride:** The hepatotoxicity of CCl4 is due to the formation of the highly reactive trichloromethyl free radical in the body which attacks the polyunsaturated fatty acids of the membrane of endoplasmic reticulum. Carbon tetrachloride poisoning leads rapidly to cessation of movement of large quantities of triglycerides from the liver to the plasma leading to fatty live r [6].

   If the damage is severe it leads to an abnormal increase in liver enzymes followed by hepatocellular necrosis. There is an influx of monocytes into the liver during acute and chronic CCl_4 induced hepatotoxicity causing an increase of Reactive Oxygen Species (ROS) production and a rise in Kupffer cell leukotriene production in the liver leading to imbalance between cytoprotective and cytotoxic prostanoids [7].

2. **Paracetamol:** Paracetamol is metabolically activated by cytochrome P450 to a reactive metabolite that covalently binds to protein[8]. The reactive metabolite responsible for hepatotoxicity is N-acetyl-p-benzoquinone-imine which reacts with N-acetyl cysteine [9].

   Although considered safe at therapeutic doses, in overdose, it produces a centrilobular hepatic necrosis that can be fatal [10]. Various mechanisms leading to paracetamol toxicity includes

   a. Increased formation of superoxide anions which cause lipid peroxidation (oxidative stress) via hydrogen peroxide formation [11].

   b. Decreased glutathione concentrations in centrilobular cells [12].

3. **D-galactosamine:** Galactosamine administration induces an inflammatory response in liver that biochemically and histologically resembles viral hepatitis [13]. A single administration causes hepatocellular necrosis and fatty liver [14].

   It causes appearance of specific lesions in liver cells, characterized by inhibition of nuclear RNA and protein synthesis [15].

4. **Thioacetamide:** Thioacetamide, originally used as a fungicide is a potent hepatotoxic and is bioactivated by CYP450 and/or flavin-containing monooxygenase (FMO) systems to sulfine (sulfoxide) and sulfene (sulfone) metabolites, which causes centrilobular necrosis [16, 17].

   This metabolite causes liver fibrosis. Thioacetamide interferes with the movement of RNA from the nucleus to cytoplasm which may cause membrane injury [18].

In the present study, the authors have reviewed the hepatoprotective activity of medicinal plants evaluated in carbon tetrachloride, paracetamol, D-galactosamine and thioacetamide induced hepato-toxicity.

TABLE 1: HEPATOPROTECTIVE ACTIVITY OF MEDICINAL PLANTS IN CARBON TETRACHLORIDE INDUCED HEPATOTOXICITY

Plant	Family	Part used	Type of extract	Test dose	Carbon tetrachloride dose
Casuarina equisetifolia, [19]	Casuarinaceae	Leaf & bark	Methanol	i.p 250mg/kg, 500mg/kg	i.p 3ml/kg
Cajanus cajan, [19]	Papilionaceae	Whole plant	Methanol	i.p 250mg/kg, 500mg/kg	i.p 3ml/kg
Glycosmis pentaphylla, [19]	Rutaceae	Leaf, bark	Methanol	i.p 250mg/kg, 500mg/kg	i.p 3ml/kg
Bixa orellana, [19]	Bixaceae	Seed	Methanol	i.p 250mg/kg, 500mg/kg	i.p 3ml/kg
Physalis minima, [19]	Solanaceae	Whole plant	Methanol	i.p 250mg/kg, 500mg/kg	i.p 3ml/kg
Argemone Mexicana, [19]	Papavaraceae	Leaf & flower	Methanol	i.p 250mg/kg, 500mg/kg	i.p 3ml/kg
Caesalpinia bonduc, [19]	Caesalpiniaceae	Leaf & bark	Methanol	i.p 250mg/kg, 500mg/kg	i.p 3ml/kg
Carthamus tinctorius, [20]	Compositae	Flower	Methanol	p.o 200mg/kg	p.o 1ml/kg
Ardisia solanacea, [21]	Myrsinaceae	Leaves	Alcohol	p.o 100mg/kg, 200mg/kg	s.c 2ml/kg
Delonix regia, [22]	Caesalpiniaceae	Aerial parts	Methanol	p.o 400mg/kg	p.o 2ml/kg
Aphanamixis polystachya, [23]	Meliaceae	Leaves	Ethanol	p.o 50mg/kg	i.p 2ml/kg
Coriandrum sativum, [24]	Apiaceae	Whole plant	Pulverised plant powder	p.o 5%, 10%, 15%	i.p 1ml/kg
Solanum pubescens, [25]	Solanaceae	Whole plant	Ethanol	p.o 500mg/kg	i.p 1ml/kg
Plumbago zeylanica, [26]	Plumbaginaceae	Aerial parts	Methanol	p.o 35mg/kg, 70mg/kg	i.p 0.1ml/kg
Cardiospermum helicacabum, [27]	Sapindaceae	Stem	Petroleum ether, methanol, water, choloroform, ethylacetate	p.o 200mg/kg, 400mg/kg	p.o 1.5ml/kg
Luffa acutangula, [28]	Cucurbitaceae	Leaves	Ethanol	p.o 200mg/kg, 400mg/kg, 600mg/kg	p.o 1ml/kg
Epaltes divaricata, [29]	Compositae	Whole plant	Aqueous	p.o 0.9g/kg	i.p 0.5ml/kg
Tagets erecta, [30]	Asteraceae	Flowers	Ethanol	p.o 400mg/kg	p.o 1875g/kg
Zizphus rotundifolia, [31]	Rhamnaceae	Leaves	Ethanol	p.o 650mg/kg	p.o 1.25ml/kg
Millettia aboensis, [32]	Fabaceae	Roots	Ethanol, aqueous	p.o 215mg/kg, 431mg/kg	i.p 0.7ml/kg
Ficus carica, [33]	Moraceae	Leaves	Methanol	p.o 500mg/kg	p.o 1.5ml/kg
Alchornea cordifolia, [34]	Euphorbiaceae	Leaves	Hexane, methanol, chloroform, ethyacetate, acetone	p.o 300mg/kg	i.p 1.25ml/kg
Morus alba, [35]	Moraceae	Leaves	Petroleum ether, chloroform, alcohol, aqueous	p.o 125mg/kg, 150mg/kg, 175mg/kg, 250mg/kg, 300mg/kg, 350mg/kg	s.c 2ml/kg
Leucophyllum frutescens, [36]	Scrophuraleaceae	Aerial parts	Methanol	p.o 100mg/kg, 200mg/kg	p.o 2ml/kg
Carissa carandas, [37]	Apocynaceae	Roots	Ethanol	p.o 100mg/kg, 200mg/kg,	i.p 0.7ml/kg

				400mg/kg	
Sesamum indicum,[38]	Pedaliaceae	Seeds	Methanol	p.o 200mg/kg, 400mg/kg, 800mg/kg	s.c 2ml/kg
Flacourtia indica,[39]	Flacourtiaceae	Leaves	Aqueous	p.o 250mg/kg, 500mg/kg	p.o 1.5ml/kg
Hippophae rhamnoides,[40]	Elaegnaceae	Leaves	Aqueous	p.o 100mg/kg, 400mg/kg	p.o 1ml/kg
Apium graveolens,[41]	Apiaceae	Seeds	Acetone, methanol, petroleum ether	p.o 250mg/kg	p.o 1.5ml/kg
Croton oblangifolius,[41]	Euphorbiaceae	Whole plant	Acetone, methanol, petroleum ether	p.o 200mg/kg	p.o 1.5ml/kg
Hypericum japonicum,[42]	Hypericaceae	Whole plant	Water, petroleum ether, chloroform	p.o 0.5, 1.5, 4.5g/kg	i.p 10ml/kg
Cinnamomum zeylanicum[43]	Lauraceae	Bark	Ethanol	p.o 0.05g/kg, 0.005g/kg, 0.01g/kg, 0.1g/kg	i.p 0.5ml/kg
Launea intybacea,[44]	Asteraceae	Aerial parts	Aqueous	p.o 200mg/kg	p.o 3ml/kg
Mimosa pudica,[45]	Mimosaceae	Leaves	Methanol	p.o 200mg/kg	i.p 1.25ml/kg
Polygala javana,[46]	Polygalaceae	Whole plant	Ethanol	p.o 100mg/kg, 200mg/kg	i.p 2.5ml/kg
Marsilea minuta,[47]	Marsileaceae	Whole plant	Methanol, toulene, aqueous, n-butyl alcohol	p.o 50mg/kg, 100mg/kg	p.o 1ml/kg
Ficus bengalensis,[48]	Moraceae	Leaves	Ethanol	p.o 100mg/kg, 200mg/kg, 400mg/kg	i.p 2ml/kg
Chenopodium album,[49]	Chenopodiaceae	Aerial parts	Ethyl acetate, methanol	p.o 300mg/kg	i.p 1ml/kg
Psidium guajava,[50]	Myrtaceae	Leaves	Methanol	p.o 250mg/kg, 500mg/kg	i.p 1ml/kg
Luffa acutangula,[51]	Cucurbitaceae	Fruits	Hydroalcohol	p.o 100mg/kg, 200mg/kg	i.p 1ml/kg
Rhododendron arboretum,[52]	Ericaceae	Leaves	Ethanol	p.o 40mg/kg, 60mg/kg, 100mg/kg	s.c 1ml/kg
Diteracanthus patulus,[53]	Acanthaceae	Leaves	Methanol	p.o 250mg/kg, 500mg/kg	i.p 1ml/kg
Cuscuta reflexa,[54]	Cuscutaceae	Aerial parts	Ethanol	p.o 1g/kg	i.p 0.1ml/kg
Crassocephalum crepidioides,[55]	Asteraceae	Whole plant	Aqueous	i.p 5ml/kg	s.c 2ml/kg
Glycyrrhiza glabra,[56]	Fabaceae	Root	Crude powder	p.o 1000mg/kg	s.c 3ml/kg
Gundelia tourenfortii,[57]	Asteraceae	Footstalks	Hydroalcohol	i.p 100mg/kg, 300mg/kg	i.p 3ml/kg
Coptidis rhizome,[58]	Ranunculaceae	Whole plant	Aqueous	p.o 400mg/kg, 600mg/kg, 800mg/kg	i.p 1ml/kg
Carica papaya,[59]	Caricaceae	Seeds	Aqueous	p.o 100mg/kg, 200mg/kg, 400mg/kg	i.p 1.5ml/kg
Cichorium intybus,[60]	Asteraceae	Leaves	70% ethanol	p.o 50mg/kg, 100mg/kg, 200mg/kg	i.p 3ml/kg

Scoparia dulcis,[61]	Scrophulariaceae	Whole plant	Petroleum ether, diethylether, methanol	p.o 50mg/kg, 200mg/kg, 800mg/kg	i.p 2ml/kg
Indigofera tinctoria,[62]	Leguminosae-papilionatae	Whole plant	Acetone, methanol, chloroform	p.o 500mg/kg	0.5mM perfusion
Solanum trilobactum,[63]	Solanaceae	Whole plant	Methanol	p.o 150mg/kg, 200mg/kg, 250mg/kg	i.p 1ml/kg
Pterocarpus marsupium,[64]	Papilionaceae	Stem bark	Aqueous, methanol	p.o 25mg/kg	i.p 0.1ml/kg
Pterocarpus santalinus,[65]	Fabaceae	Stem bark	70% ethanol	p.o 30mg/kg, 45mg/kg	i.p 0.1ml/kg
Curculigo orchioides,[66]	Amaryilidaceae	Rhizomes	Methanol	p.o 70mg/kg	s.c 1ml/kg
Phoenix dactylifera,[67]	Palmae	Fruit	Aqueous	Ad libitum in place of rat chow	i.p 2ml/kg
Asteracantha longifolia,[68]	Acanthaceae	Whole plant	Aqueous	p.o 900mg/kg	i.p 0.5ml/kg
Strychnos potatorum,[69]	Loganiaceae	Seeds	Aqueous, seed powder	p.o 100mg/kg, 200mg/kg	s.c 3ml/kg
Vitex trifolia,[70]	Verbenaceae	Leaves	Aqueous, ethanol	p.o 20mg/kg, 30mg/kg	i.p 0.1ml/kg
Capparis spinosa,[71]	Capparidaceae	Root bark	Ethanol	p.o 100mg/kg, 200mg/kg, 400mg/kg, 800mg/kg	p.o 0.2mg/kg
Lawsonia alba,[72]	Lythraceae	Bark	50% ethanol	p.o 250mg/kg, 500mg/kg	p.o 1ml/kg
Carissa opaca,[73]	Apocyanaceae	Leaves	Methanol	p.o 200mg/kg	i.p 0.5ml/kg

TABLE 2: HEPATOPROTECTIVE ACTIVITY OF MEDICINAL PLANTS IN PARACETAMOL INDUCED HEPATOTOXICITY

Plant	Family	Part used	Type of extract	Test dose	Paracetamol dose
Azima tetracantha,[74]	Salvadoraceae	Leaves	Ethanol	p.o 250mg/kg, 500mg/kg	p.o 2g/kg
Dragea volubilis,[75]	Asclepiadaceae	Fruits	Petroleum ether	p.o 100mg/kg, 200mg/kg	p.o 650mg/kg
Coccinia indica,[76]	Cucurbitaceae	Fruits	aqueous	p.o 200mg/kg, 400mg/kg	p.o 2g/kg
Sida rhombifolia,[77]	Malvaceae	Whole plant	Ethanol	p.o 100mg/kg, 200mg/kg	p.o 2g/kg
Psidium guajava,[78, 50]	Myrtaceae	Leaves	Ethanol[60] Methanol[32]	p.o (200mg/kg, 400mg/kg)[60], (250mg/kg, 500mg/kg)[32]	p.o 835mg/kg[60], 1g/kg[32]
Solanum pubscens,[79]	Solanaceae	Leaves	Methanol	p.o 300mg/kg	p.o 3g/kg
Tabebuia rosea,[79]	Bignoniaceae	Leaves	Methanol	p.o 500mg/kg	p.o 3g/kg
Ichnocarpus frutescens,[80]	Apocyanaceae	Whole plant	Methanol, chloroform	p.o 250mg/kg, 500mg/kg	p.o 750mg/kg
Vanilla planifolia,[81]	Orchidaceae	Beans	Ethanol	p.o 100mg/kg	p.o 500mg/kg
Nilgirianthus ciliates,[82]	Acanthaceae	Bark	Methanol	p.o 250mg/kg, 500mg/kg	p.o 2.5g/kg
Phyllanthus niruri,[83]	Phylanthaceae	Leaves	Aqueous	p.o 440mg/kg	p.o 500mg/kg
Aegle marmelos,[83]	Rutaceae	Leaves	Aqueous	p.o 440mg/kg	p.o 500mg/kg
Aloe vera,[83]	Xanthorrhoeaceae	Leaves	Aqueous	p.o 440mg/kg	p.o 500mg/kg
Eclipta alba,[83]	Asteraceae	Leaves	Aqueous	p.o 440mg/kg	p.o 500mg/kg
Solanum indicum,[83]	Solanaceae	Leaves	Aqueous	p.o 440mg/kg	p.o 500mg/kg

Maytenus emarginata,[83]	Celastraceae	Leaves	Aqueous	p.o 440mg/kg	p.o 500mg/kg
Aerva lanata,[84]	Amaranthaceae	Whole plant	Hydroalcohol	p.o 200mg/kg	p.o 3g/kg
Aerva sanguinolenta,[85]	Amaranthaceae	Leaves	Ethanol	p.o 200mg/kg, 400mg/kg	p.o 640mg/kg
Gymnosporia emerginata,[86]	Clasteraceae	Whole plant	Methanol	p.o 300mg/kg	p.o 3g/kg
Marsedenia volubillis,[86]	Asclepiadaceae	Whole plant	Methanol	p.o 500mg/kg	p.o 3g/kg
Carissa carandas,[87]	Apocyanaceae	Roots	Ethanol	p.o 100mg/kg, 200mg/kg, 400mg/kg	p.o 2000mg/kg
Asparagus racemosa,[88]	Liliaceae	Roots	Aqueous	p.o 150mg/kg, 200mg/kg	p.o 500mg/kg
Kigelia Africana,[89]	Bignoniaceae	Leaves	Methanol	p.o 200mg/kg	p.o 3g/kg
Anogeissus accuminata,[89]	Combretaceae	Leaves	Methanol	p.o 300mg/kg	p.o 3g/kg
Abelmoschus moschatus,[90]	Malvaceae	Seeds	Aqueous	p.o 300mg/kg	p.o 500mg/kg
Cyperus articulates,[91]	Cyperaceae	Rhizome	Methanol	p.o 200mg/kg, 400mg/kg	p.o 640mg/kg
Thymus capitatus,[92]	Lamiaceae	Essential oils	Steam distillation	p.o 50mg/kg	p.o 500mg/kg
Salvia officinalis,[92]	Lamiaceae	Essential oils	Steam distillation	p.o 50mg/kg	p.o 500mg/kg
Solidago microglossa,[93]	Compositae	Leaves	Ethanol	p.o 100mg/kg, 200mg/kg	p.o 250mg/kg
Macrotyloma uniflorum,[94]	Fabaceae	Seeds	Methanol	p.o 200mg/kg, 400mg/kg	p.o 2g/kg
Tridax procumbens,[95]	Compositae	Whole plant	Ethanol	p.o 100mg/kg, 200mg/kg, 300mg/kg, 400mg/kg	p.o 2g/kg
Dipteracanthus patulus,[53]	Acanthaceae	Leaves	Methanol	p.o 250mg/kg, 500mg/kg	p.o 2g/kg
Orthosiphon stamineus,[96]	Lamiaceae	Leaves	Methanol	p.o 100mg/kg, 200mg/kg	p.o 2g/kg
Desmodium oojeinense,[97]	Fabaceae	Bark	Ethanol	p.o 100mg/kg, 200mg/kg, 400mg/kg	p.o 2g/kg
Trianthema portulacastrum,[98]	Aizoaceae	Whole plant	Alcohol, aqueous	p.o 100mg/kg	p.o 3g/kg
Acacia chatechu,[99]	Mimosaceae	Heartwood	Ethanol	p.o 250mg/kg	p.o 250mg/kg
Feronia limonia,[100]	Rutaceae	Fruits	Ethanol	p.o 100mg/kg, 200mg/kg, 300mg/kg	p.o 500mg/kg
Tecomella undulate,[101]	Bignoneaceae	Leaves	Methanol	p.o 100mg/kg, 200mg/kg	p.o 500mg/kg
Baliospermum montanum,[102]	Euphorbiaceae	Roots	Chloroform, alcohol, aqueous	p.o 200mg/kg	p.o 2g/kg
Cyathea gigantean,[103]	Cyatheaceae	Leaves	Methanol	p.o 100mg/kg, 200mg/kg	p.o 1g/kg
Asteracantha longifolia,[68]	Acanthaceae	Whole plant	Aqueous	p.o 900mg/kg	p.o 300mg/kg
Operculina turpethum,[104]	Convolvulaceae	Roots	Ethanol	p.o 200mg/kg	p.o 3g/kg
Tamarindus indica,[105]	Caesalpiniaceae	Fruits, seeds, leaves	Aqueous	p.o 350mg/kg, 700mg/kg	p.o 1g/kg
Berberis tinctoria,[106]	Berneridaceae	Leaves	Methanol	p.o 150mg/kg, 300mg/kg	p.o 750mg/kg
Azadirachta indica,[107]	Meliaceae	Leaves	70% ethanol	p.o 500mg/kg	p.o 2g/kg
Ceiba pentandra,[108]	Bombacaceae	Stem bark	Ethylacetate	p.o 400mg/kg	p.o 3g/mg
Plumbago zeylanica,[109]	Plumbaginaceae	Roots	Petroleum ether	p.o 300mg/kg	p.o 400mg/kg
Phyllanthus emblica,[110]	Euphorbiaceae	Fruits	Aqueous	p.o 100mg/kg, 200mg/kg	p.o 2g/kg

TABLE 3: HEPATOPROTECTIVE ACTIVITY OF MEDICINAL PLANTS IN D-GALACTOSAMINE INDUCED HEPATOTOXICITY

Plant	Family	Part used	Type of extract	Test dose	D-galactosamine dose
Pittosporum neelgherrense,[111]	Pittosporaceae	Stem bark	Methanol	p.o 100mg/kg, 200mg/kg, 300mgkg	i.p 400mg/kg
Sphaeranthus amaranthoides,[112]	Compositae	Whole plant	Ethanol	p.o 500mg/kg	i.p 500mg/kg
Olenlandia herbaceae,[113]	Rubiaceae	Whole plant	Methanol	p.o 100mg/kg, 200mg/kg	i.p 200mg/kg
Calotropis gigantean,[114]	Ascelpiadaceae	Root bark	Ethanol	p.o 200mg/kg, 400mg/kg	i.p 400mg/kg
Coldenia procumbens,[115]	Boraginaceae	Whole plant	Methanol, chloroform	p.o 200mg/kg, 400mg/kg	i.p 400mg/kg
Portulaca oleraceae,[116]	Portulacaceae	Whole plant	Methanol, petroleum ether	p.o 200mg/kg, 400mg/kg	i.p 400mg/kg
Betula utilis,[117]	Betulaceae	Bark	Ethanol, aqueous	p.o 100mg/kg, 200mg/kg	i.p 400mg/kg
Pterocarpus santalinus,[118]	Fabaceae	heartwood	chloroform	p.o 200mg/kg, 400mg/kg	i.p 400mg/kg
Santolina chamaecyparissus,[119]	Asteraceae	Whole plant	Ethanol	p.o 250mg/kg	i.p 400mg/kg
Macrotyloma uniflorum,[94]	Fabaceae	Seeds	Methanol	p.o 200mg/kg, 400mg/kg	i.p 400mg/kg
Polygala arvensis,[120]	Polygalaceae	Leaves	Chloroform	p.o 200mg/kg, 400mg/kg	i.p 400mg/kg
Enicostemma axillare,[121]	Gentianaceae	Whole plant	Ethylacetate	p.o 100mg/kg, 200mg/kg	i.p 200mg/kg
Solanum tuberosum (purple potato),[122]	Solanaceae	Tubers	Formic acid, disttiled water	p.o 400mg/kg	i.p 250mg/kg
Crassocephalum crepidioides,[55]	Asteraceae	Whole plant	Aqueous	i.p 5ml/kg	i.p 400mg/kg
Garcinia kola,[123]	Guttifera	Seeds	Methanol	p.o 100mg/kg	1.p 800mg/kg
Fumaria indica pugsley,[124]	Fumariaceae	Whole plant	50%ethanol, butanol, chloroform	p.o 200mg/kg, protopine 50mg/kg	i.p 400mg/kg
Leucas lavandulaefolia,[125]	Labiatae	Leaves	Methanol	p.o 100mg/kg	i.p 800mg/kg
Indigofera tinctoria,[62]	Leguminaceae	Whole plant	Acetone, methanol, chloroform	p.o 500mg/kg	5mM perfusion

TABLE 4: HEPATOPROTECTIVE ACTIVITY OF MEDICINAL PLANTS IN THIOACETAMIDE INDUCED HEPATOTOXICITY

Plant	Family	Part used	Type of extract	Test dose	Thioacetamide dose
Pisonia aculeate,[126]	Nyctaginaceae	Whole plant	Methanol	p.o 250mg/kg, 500mg/kg	s.c 50mg/kg
Phyllanthus niruri,[127]	Phyllanthaceae	Whole plant	Ethanol	p.o 200mg/kg	i.p 200mg/kg
Vitex negundo,[128]	Lamiaceae	Leaves	Ethanol	p.o 100mg/kg, 300mg/kg	0.03% in drinking water
Orthosiphon stamineus,[129]	Lamiaceae	Leaves	Ethanol	p.o 100mg/kg, 200mg/kg	i.p 200mg/kg
Momordica tuberose,[130]	Cucurbitaceae	Tubers	Ethanol	p.o 20mg/kg, 40mg/kg	s.c 100mg/kg
Tinispora crispa,[131]	Menispermaceae	Stem	Ethanol	p.o 100mg/kg, 200mg/kg	i.p 200mg/kg
Zizyphus jujube,[132]	Rhamnaceae	Fruits	Methanol	p.o 250mg/kg,	s.c 100mg/kg

				500mg/kg, 1000mg/kg	
Phoenix dactylifera, [133]	Aracaceae	Fruits	Aqueous	p.o 4ml/kg	i.p 400mg/kg
Gardenia gummifera, [134]	Rubiaceae	Roots	Methanol	p.o 125mg/kg, 250mg/kg	s.c 100mg/kg
Albizzia lebbeck, [135]	Fabaceae	Leaves	70% Ethanol	p.o 100mg/kg, 200mg/kg	s.c 100mg/kg
Wedelia calendulaceae, [136]	Compositae	Leaves	Methanol	p.o 100mg/kg, 200mg/kg, 400mg/kg	s.c 100mg/kg
Ceiba pentandra, [137]	Bombacaceae	Root	Methanol	p.o 200mg/kg, 400mg/kg	s.c 50mg/kg
Ipomoea aquatica, [138]	Convolvulaceae	Leaves	Ethanol	p.o 250mg/kg, 500mg/kg	i.p 200mg/kg
Boerhaavia diffusa, [139]	Nyctaginaceae	Stem, leaves	Alcohol, aqueous	p.o 150mg/kg, 300mg/kg	s.c 50mg/kg
Anisochilus carnosus, [139]	Nyctaginaceae	Leaves	Alcohol, aqueous	p.o 200mg/kg, 400mg/kg	s.c 50mg/kg
Phyllanthus acidus, [140]	Euphorbiaceae	Leaves	Ethanol, aqueous	p.o 200mg/kg, 400mg/kg	s.c 100mg/kg
Artemisia aucheri, [141]	Compositae	Flowered branches	Ethanol	i.p 100mg/kg, 200mg/kg	i.p 50mg/kg
Nigella sativa, [142]	Ranunculaceae	Seed oil		p.o 5ml/kg, 10ml/kg	i.p 20mg/kg
Curcuma longa, [143]	Zingiberaceae	Rhizome	Ethanol	p.o 250mg/kg, 500mg/kg	i.p 200mg/kg
Capparis deciduas, [144]	Capparaceae	Root bark	Ethanol	p.o 300mg/kg, 600mg/kg	s.c 400mg/kg
Bosenbergia rotunda, [145]	Zingiberaceae	Rhizomes	Ethanol	p.o 250mg/kg, 500g/kg	i.p 200mg/kg
Feronia elephantum, [146]	Rutaceae	Leaves	Aqueous	p.o 400mg/kg, 800mg/kg	i.p 300g/kg

CONCLUSION: From this study, it is clear that many medicinal plants process significant hepatoprotective activity. Our review will help researchers to choose different herbs and blend it to a formulation which could be an effective treatment for various liver diseases.

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